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CANCER OF THE LARYNX

Five Year Results of Concentration Radiotherapy

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THIS is a report on 118 consecutive patients with cancer of the larynx who were treated by irradiation in the Chicago Tumor Institute from the time it opened in April 1938 through December 1942.[1] The most recent of these was treated more than three years ago, but the main conclusions are based on the results observed in 47 treated in 1938, 1939 and 1940, with a minimum observation period of five years.

The main purpose is to discuss the advances in the radiation treatment of laryngeal cancer, with special reference to concentration radiotherapy, and to analyze the extent to which these and other results call for a revision of opinion on the present day treatment of this disease. The main point of issue is under what circumstances radiotherapy should be used for operable cancer of the larynx. More specifically, the following questions are discussed:

1. Should radiotherapy be preferred to surgical treatment for early carcinoma of the true cord amenable to laryngofissure?

2. Should radiotherapy be preferred to surgical treatment for operable intrinsic carcinoma of the larynx when the disease is so advanced as to require total laryngectomy?

CONCENTRATION RADIOTHERAPY

The principles and technic of this method have been recorded.[2] The basic principle is that large daily doses are given over a comparatively short period. The total dose is sufficient to cause an "epithelite" and

From the Chicago Tumor Institute.

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1. Fifty-two patients were selected for treatment at the institute from among those seen at the Veterans Administration Facility, Hines, Ill.

2. Cutler, M.: (*a*) Concentration Method of Radiotherapy for Cancer of the Mouth, Pharynx and Larynx, J. A. M. A. **117**:1607 (Nov. 8) 1941; (*b*) Concentration Radiotherapy of Cancer of the Larynx: A Study of 413 Cases, ibid. **124**: 967 (April 1) 1944; (*c*) Concentration Method of Radiotherapy for Cancer of the Mouth, Pharynx and Larynx, Am. J. Roentgenol. **51**:739 (June) 1944.

usually also an "epidermite." With certain exceptions, the dose is increased daily and the size of the cutaneous portal is diminished. The optimal period of treatment is not yet definitely established. The method of irradiation now generally used for cancer of the larynx is the divided dose technic, known as the Coutard method.[3] Roentgen treatments are given daily to two lateral fields. The period of treatment varies between four and seven weeks and the total dose between 6,000 and 7,000 roentgens (r). This method does not cure the more radioresistant types of carcinoma. Concentration radiotherapy is much more intense. Instead of 6,000 to 7,000 r being given in four to seven weeks to two fields, 6,000 to 6,500 r is administered in eighteen days to one field. There was every reason to believe that more intense irradiation would be more effective in the more radioresistant types of carcinoma. The question was how to adjust the various factors to render the treatment reasonably safe. The following considerations are important:

Voltage—Roentgen Intensity and Fields.—The higher voltage appears to have advantages. Most of the patients are treated with 400 kilovolt roentgen rays. In a small group 200 kilovolt roentgen rays are being used in order that the end results may be compared. The roentgen intensity has varied between 5 and 10 r per minute. Except on special indications, one lateral field is used. Because the central remnant of the regressing carcinoma is its most radioresistant portion, the field is reduced gradually as the daily dose is increased. The greatest precision is necessary with the use of small fields. A light-centering device and an adjustable diaphragm are indispensable for accurate localization. Great care must be taken in immobilizing the patient, and the setup must be checked at frequent intervals during the treatment.

Time (Total Number of Days of Treatment).—The question of the optimal time over which a given cancer should be irradiated has been a subject of study for many years. One important fact emerges: Within certain still undefined limits, the more radioresistant the lesion is, the shorter must be the time of treatment and the larger the daily dose. A superficial papillary carcinoma of the true cord, for example, can be sterilized with 6,000 r given through two portals and divided equally over a period of thirty to forty days. A carcinoma of the true cord that has infiltrated the muscle and caused complete fixation, as a rule, cannot be sterilized by this method but requires more intensive irradiation in the form of larger daily doses, 6,000 r being given through one portal in eighteen days or less. The evidence clearly indicates that the more radioresistant lesions require not only a maximum total

3. Coutard, H.: Roentgen Therapy of Epitheliomas of Tonsillar Region, Hypopharynx and Larynx from 1920 to 1926, Am. J. Roentgenol. **28**:313 (Sept.) 1932.

dose but a maximum daily dose to insure their complete sterilization, and this is the fundamental basis of concentration radiotherapy.

Radium Treatment—Telecurietherapy.—The pioneer work in radium therapy was done by Janeway and Quick. In the Janeway Memorial Lecture, Quick [4] reported some striking results. Harmer [5] subsequently obtained excellent results in early lesions of the cord by applying radium through a window made by resecting a portion of the thyroid cartilage. Good results were recorded by Ahlbom [6] with telecurietherapy, also by Lederman and Mill,[7] who reported five year cures in 7 of 15 patients treated by telecurietherapy.

The apparatus for telecurietherapy of the Chicago Tumor Institute contained 10 Gm. of radium until September 1943 when 3 Gm. was released for war purposes. The skin distance is 12.5 cm., the filter 1 mm. of platinum and the portal 6 by 6 cm. No definite conclusions can be stated as to the comparative value of roentgen rays and radium; all that can be said at this time is that telecurietherapy is a highly useful and reliable method and has yielded some interesting results, especially when used in accordance with the principle of concentration. Eighteen patients were treated from 1938 to 1942, inclusive. Only in 6 was the lesion of the cord in an early stage. Five had metastases in the cervical nodes. Six patients are well and free of disease more than three years.

Present Technic.—Numerous technics have been tested, the principal variation being in the total number of days of treatment and the size of the fields. Treatment periods of four to twenty-two days have been tried, and the matter of the optimal period is still not settled. One technic with an eleven day period has yielded excellent results but has proved too intense for certain patients. This led to the period's being increased to eighteen days. So far there have been no untoward effects, but not enough time has elapsed to be certain. Should the eighteen day treatment reduce or eliminate the radiation complications, there is reason to believe that it will be equally or almost equally effective with respect to sterilizing the carcinoma. The "interval treatment" previously published [1b] is now being limited to patients with advanced,

4. Quick, D.: Carcinoma of the Larynx, Am. J. Roentgenol. **38**:821 (Dec.) 1937.

5. Harmer, W. D.: The Relative Value of Radiotherapy in the Treatment of Cancers of the Upper Air Passages, University of London Semon Lecture, London, John Murray, 1932.

6. Ahlbom, H. E.: Die Resultate der Strahlenbehandlung von endolaryngealen Karzinomen am Radiumhemmet, Stockholm, von 1930 bis 1939, Acta radiol. **22**: 539, 1941.

7. Lederman, M., and Mill, W. A.: The Teleradium Treatment of Intrinsic Cancer of the Larynx, J. Laryng. & Otol. **52**:471 (Nov.) 1942.

inoperable lesions. This technic has yielded some most dramatic results in apparently hopeless cases. An adjustment of certain factors is now being made to render it safer.

The following two roentgen ray technics are in general use in the Chicago Tumor Institute. They are in no sense considered as final but are presented as one stage in the course of these studies.

1. For early intrinsic carcinoma of one or both true or false cords with complete or partial mobility: 400 kilovolts, 5 milliamperes; filter, 5 mm. of copper; distance, 84 to 115 cm.; single lateral port, 5 by 5 cm. gradually diminished to 3 by 3 cm.; average intensity, about 7 r per minute; rate of treatment, two equal treatments daily for eighteen days, beginning with 100 r twice a day and increasing to 250 r twice a day; total dose, 6,000 r measured on the skin.
2. For more extensive intrinsic and for extrinsic carcinoma with or without regional cervical metastases and with partial or complete fixation: 400 kilovolts, 5 milliamperes; filter, 7 to 8 mm. of copper; distance, 75 to 80 cm.; single lateral port, 7 by 5 cm. gradually diminished to 4 by 3 cm.; average intensity, about 6 r per minute; rate of treatment, two equal treatments for eighteen days, beginning with 85 r twice a day and increasing to 275 r twice a day; total dose, 6,500 r measured on the skin. When the metastases are too extensive to be included in the fields, additional irradiation is given to such areas.

The most effective telecurietherapy technic has been the following: total dose, 72,000 milligram hours to each of two lateral fields; radium content, 7 to 10 Gm.; distance, 12.5 cm.; field, 6 by 6 cm.; rate of administration, two treatments daily for twelve days, the dose being increased from 2,000 milligram hours to each side daily to 10,000 milligram hours to each side daily.

Complications.—Two patients died as a direct result of radionecrosis. One, a youth aged 19 years, had a lesion of the right hemilarynx, involving the true cord, the false cord and the subglottic area. He received a total of 6,600 r to two lateral fields in eleven days. He died of hemorrhage of the larynx eleven months later. Autopsy showed no evidence of carcinoma. The other patient had a lesion of the anterior two thirds of one cord. He received a total of 190,000 milligram hours with the 10 Gm. radium pack in ten treatment days. The first cycle of six days and the second cycle of four days were separated by an interval of eleven days. Death from necrosis occurred nine months later. There was no evidence of carcinoma. In 7 other patients who died, varying degrees of necrosis were present, but in all the cancer was so advanced and the illness so severe that these factors and not the irradia-

tion are accountable for the results. The general condition of the patient has much to do with the intensity of the irradiation that can be tolerated. Any condition that lowers the resistance of the tissues, such as syphilis, diabetes or severe arteriosclerosis, renders them more vulnerable to injury by irradiation and increases the chances of untoward effects. Finally, infection is probably the most important single contributing factor. Fortunately, the sulfonamide compounds and penicillin are of great value in the prevention and the treatment of the infectious complications of irradiation.

Results.—The main point of this research has been to devise a technic that would permit irradiation intense enough to cure the more radioresistant forms of laryngeal cancer, i. e., those which are not cured by the generally used divided dose technic, and at the same time to avoid serious complications of irradiation. Concentration radiotherapy

TABLE 1.—*Five Year Results of Radiotherapy in Relation to Extent of Carcinoma and Mobility of Laryngeal Structures*

	Total Number of Patients		1938		1939		1940	
Stage of Carcinoma	Treated	Well	Treated	Well	Treated	Well	Treated	Well
Cords movable or partly fixed	17	11	6	3	6	4	5	4
Cords fixed; advanced cancer; regional metastasis	30	7	13	3	8	2	9	2
Total	47	18	19	6	14	6	14	6

Eighteen five year cures, or 42 per cent

Note.—Four patients died from other causes than cancer: 1, from cerebral hemorrhage two years after treatment; 1, from coronary disease three years and four months after treatment; 1, from perforation of gastric ulcer three years and five months after treatment; 1, from cerebral metastasis four years and four months after treatment. In none of these was there any local recurrence of cancer.

has resulted in cure of laryngeal cancers (extrinsic and intrinsic) not curable by the less intense divided dose technic.[8] The effect has been especially significant in intrinsic carcinoma of the larynx technically amenable to laryngectomy but too advanced for laryngofissure, because here laryngectomy is the only alternative to irradiation. Tables 1 and 2 show the five year results in 47 consecutive patients. In table 1 the patients are classified on the basis of mobility of the cords; in table 2, on the basis of surgical indications. Tables 3 and 4 show the three year results in 118 consecutive patients similarly classified.

Significance of Three Year Results in Patients with Laryngeal Cancer.—Between 1938 and 1942 inclusive, 52 patients died of uncontrolled

8. The diagnosis was confirmed by biopsy in all but 6 cases. In these either no biopsy was made or an inadequate biopsy was not repeated for special reasons. There is no doubt whatever about the clinical diagnosis.

cancer following irradiation. Of these, 33 (63 per cent) died during the first year, 13 (25 per cent) during the second year, 5 (10 per cent) during the third year and 1 (2 per cent) in the fifth year. Thus, 88 per cent were dead within two years and 98 per cent within three years. In Lenz's [9] series of 87 cases 90 per cent of deaths from uncontrolled cancer occurred within three years of treatment. These findings indicate that three year statistics for cancer of the larynx are fairly

TABLE 2.—*Five Year Results of Radiotherapy in Relation to Operability and Surgical Indications*

Stage of Carcinoma and Surgical Indications	Total Number of Patients		1938		1939		1940	
	Treated	Well	Treated	Well	Treated	Well	Treated	Well
Extrinsic, inoperable.....	31	8	14	3	8	3	9	2
Intrinsic, suitable for laryngectomy.....	9	5	4	3	4	1	1	1
Intrinsic, suitable for laryngofissure.....	7	5	1	0	2	2	4	3
Total.....	47	18						

Eighteen five year cures, or 42 per cent

See note, table 1, about 4 patients dying from other causes than cancer.

TABLE 3.—*Three Year Results of Radiotherapy in Relation to Extent of Carcinoma and Mobility of Laryngeal Structures*

Stage of Carcinoma	Total Number of Patients		1938		1939		1940		1941		1942	
	Treated	Well	Treated	Well	Treated	Well	Treated	Well	Treated	Well	Treated	Well
Cords movable or partly fixed.....	41	25	6	3	6	4	5	4	15	7	9	7
Cords fixed; advanced cancer; regional metastasis.....	77	18	13	3	8	2	9	2	26	6	21	5
Total.....	118	43										

Note.—Eight patients died from other causes than cancer (without recurrence), leaving 43 three year cures in 110 cases, or 39 per cent. Of the 8 patients who died from other causes than cancer, 1 died of perforated gastric ulcer one year after treatment; 2, of coronary disease, 1 one year and seven months and the other three years and eight months after treatment; 1, of cancer of the prostate two years after treatment. For details of the deaths of the other 4 see note, table 1.

reliable and not to be compared with those for cancer of the breast or of the thyroid, for example, the inadequacy of which is known.

Discussion of Statistics.—Tables 1 and 2 show results in 47 consecutive patients who were observed more than five years. Four patients

9. Lenz, M.: Causes of Failure of Roentgen Therapy in Cancer of the Larynx, Am. J. Roentgenol. **46**:21 (July) 1941.

are deducted, having died of other causes.[9a] Eighteen patients (42 per cent) are well and free of disease more than five years. Tables 3 and 4 show results in 118 patients who were observed more than three years. Eight patients died of other causes without local recurrence more than one year after treatment, leaving 110, 43 of whom (39 per cent) are well and free of disease. As expected, the five year and the three year results are remarkably parallel. It is noted that 42 per cent five year cures and 39 per cent three year cures were obtained in a group of consecutive, unselected patients, showing all stages of the disease. It is further noted that in the five year group (table 2) 31 of 47 lesions were extrinsic and inoperable, and in the three year group (table 4) 75 of 118 (approximately two thirds) were advanced and inoperable. Only 17 of the 118 (14 per cent) cancers were early

TABLE 4.—*Three Year Results of Radiotherapy in Relation to Operability and Surgical Indications*

Stage of Carcinoma and Surgical Indications	Total Number of Patients		1938		1939		1940		1941		1942	
	Treated	Well	Treated	Well	Treated	Well	Treated	Well	Treated	Well	Treated	Well
Extrinsic, inoperable	75	18	14	3	8	3	9	2	24	4	20	6
Intrinsic, suitable for laryngectomy	26	13	4	3	4	1	1	1	11	6	6	2
Intrinsic, suitable for laryngofissure	17	12	1	0	2	2	4	3	6	3	4	4
Total	118	43										

Forty-three three year cures, or 39 per cent

See note, table 3, about 8 patients dying from other causes than cancer.

enough for laryngofissure, and 26 of 118 (22 per cent) were operable by laryngectomy. New and Waugh[10] reported 56.1 per cent five year cures obtained with laryngectomy. The results obtained at the Chicago Tumor Institute with concentration radiotherapy compare favorably with theirs. Table 4 shows 26 patients whose cancers were amenable to laryngectomy and beyond the reach of laryngofissure. Three are deducted as having died of other causes, leaving 23, 13 of whom are well and free of disease more than three years (2 are well three years, 6 are well four years, 1 is well five years, 1 is well six years and 3 are well seven years).

9a. One died of cerebral metastasis four years and four months after treatment, without local recurrence.

10. New, G. B., and Waugh, J. M.: The Curability of Carcinoma of the Larynx, Surg., Gynec. & Obst. **58**:841 (May) 1934.

IS ONE JUSTIFIED IN CHOOSING IRRADIATION IN PREFERENCE TO SURGICAL TREATMENT FOR EARLY CARCINOMA OF THE LARYNX AMENABLE TO LARYNGOFISSURE?

Laryngofissure is a well established procedure yielding 80 to 85 per cent cures in carefully selected cases of early cancer of the vocal cords, and laryngologists will naturally hesitate to abandon such an effective method for the newer method of irradiation until adequate evidence justifies the change. The trend toward irradiation for early intrinsic cancer of the larynx began as early as 1938, when Jackson and Jackson [11] stated:

> . . . For a small, early growth located within the intrinsic area in a patient otherwise free from organic disease we would not feel justified in advising anything other than laryngofissure. On the other hand, for a patient with such a growth whose life expectancy is seriously shortened by diabetes, pulmonary tuberculosis, cardiovascular disease or other organic disease we would advise irradiation. . . . The preference is based on the fact that irradiation has now reached a degree of efficacy that renders it probable that the patient will live out his short expectancy without recurrence after irradiative arrest.

TABLE 5.—*Results of Radiotherapy in Patients with Carcinoma of the Larynx Who Ordinarily Would Be Subjected to Laryngofissure*

Year	Patients Treated	Alive at the End of							
		1938	1939	1940	1941	1942	1943	1944	1945
1938	1	1	1	0	0	0	0	0	0
1939	2	..	2	2	2	2	2	2	2
1940	4	..	..	4	4	3*	3	3	3
1940	6	..	..	..	6	5	4†	4§	4
1942	4	..	..	..	..	4	4	4	4
Total	17								

* One patient died of cerebral hemorrhage two years after treatment; there was no local recurrence.
† One patient died of carcinoma of the prostate two years after treatment; there was no local recurrence.
§ In 1 patient recurrence of the cancer necessitated laryngectomy; this patient is well.

Lenz [12] asserted that the results of roentgen therapy may be as good as those of laryngofissure and that the patient should be allowed to choose the treatment he prefers. Jackson and Blady,[13] while recognizing the value of irradiation, expressed a preference for laryngofissure because of the latter's long-established record. They pointed out, how-

11. Jackson, C., and Jackson, C. L.: Cancer of the Larynx, J. A. M. A. **111**: 1986 (Nov. 26) 1938.

12. Lenz, M.: X-Ray Treatment of Diseases of the Larynx, Tr. Am. Laryng. A. **64**:206, 1942.

13. Jackson, C. L., and Blady, J. V.: Criteria for the Selection of Treatment of Cancer of the Larynx, Arch. Otolaryng. **37**:672 (May) 1943.

ever, that when the lesion has reached the posterior extremity of the cord without impairing the cord's motility, laryngofissure is contraindicated and irradiation is to be preferred to laryngectomy. Schall [14] stated that "the ideal treatment is one that not only eradicates the disease but also leaves a normal physiological state. External irradiation answers these requirements. Laryngeal cancer that responds to irradiation leaves the patient with a normal or nearly normal voice."

Table 5 gives the results observed in all patients with cancer of the true cords amenable to laryngofissure who were treated with radiation at the Chicago Tumor Institute more than three years ago (1938 to 1942, inclusive). From the figures it seems that the results of irradiation in these patients are at least as good as those of laryngofissure. Without suggesting the abandonment of so well established a procedure as laryngofissure with its long record of favorable results, the question of choice of fissure or irradiation needs discussion. If laryngofissure is used, there should at least be strict selection of patients so that those not completely suitable for fissure may be given the benefits of irradiation. Under proper circumstances, the intelligent patient should be familiarized with the facts and given an opportunity to choose between the two procedures.

IS ONE JUSTIFIED IN CHOOSING IRRADIATION IN PREFERENCE TO LARYNGECTOMY FOR OPERABLE INTRINSIC CARCINOMA OF THE LARYNX TOO ADVANCED FOR LARYNGOFISSURE?

The operative mortality of total laryngectomy has been reduced to 1 in 60 cases (New and Waugh [10]), so that the primary risk in patients of good physical condition does not contraindicate this procedure. The high curability of 73.5 per cent cited by MacKenty [15] is explained by the fact that in a large proportion of his cases the carcinoma was a small lesion of one cord with mobility of the cord and without involvement of either commissure; such cases yield about 80 per cent cures by either laryngofissure or irradiation. The lower curability (15 per cent) reported by such pioneer laryngologists as Gluck and Soerensen [16] is due to the fact that they accepted for operation many cancers which others would have rejected as inoperable. New and Waugh [10] cited

14. Schall, L. A.: Carcinoma of the Larynx, New England J. Med. **229**:574 (Oct. 7) 1943.

15. MacKenty, J. E.: Laryngeal Cancer; Early Technics and Treatment, Arch. Otolaryng. **9**:237 (March) 1929.

16. Gluck, T., and Soerensen, J.: Die Exstirpation und Resektion des Kehlkopfes, in Katz, L., and Blumenfeld, F.: Handbuch der speziellen Chirurgie des Ohres und der oberen Luftwege, ed. 4, Leipzig, Curt Kabitzsch, 1932, vol. 4, chap. 1, p. 1.

56.1 per cent five year cures of traced patients, and Jackson [17] stated that laryngectomy should give 50 to 60 per cent cures.

The first favorable results of radiotherapy in patients with laryngeal cancer were reported by Regaud, Coutard and Hautant [18] in 1922 before the International Congress of Otology in Paris. The report dealt with 6 patients who were given roentgen treatment for advanced inoperable carcinoma of the larynx. Coutard [3] subsequently reported 27 per cent five year cures in 142 patients treated in the Curie Institute of Paris. The literature contains few recent reports of adequate statistics on the results of radiotherapy in cases of laryngeal cancer. This is not surprising because improvements in irradiation technic can have only a relatively minor effect on the ultimate results when applied exclusively to advanced lesions. Another problem is that the constant changing of the technic of irradiation makes it difficult to compare methods on a statistical basis. In 1942 Lenz [12] reported 70 patients treated with roentgen rays in the Presbyterian Hospital, New York, between 1932 and 1936. Thirteen, or 19 per cent, were free of disease in January 1942. That most of the cancers were advanced is emphasized by the fact that only 5 of the 70 patients showed a lesion limited to one vocal cord. With the improvement in radiotherapy, a slow but definite turning from operation toward irradiation has been noted, and this has resulted in several reports in which it is shown that a considerable number of operable cancers of the larynx were treated by radiotherapy with marked improvement in results. Blady and Chamberlain [19] in 1944 reported five year end results in 36 patients. In 23 the cancers were intrinsic. The net five year survival for the group with intrinsic lesions (23) was 59 per cent and that for the entire group 49 per cent. The statistics of five year end results now reported show 47 patients treated for all stages (intrinsic and extrinsic), 18 of whom, or 42 per cent, are well.[20]

The improvement in results is due to two important factors: earlier diagnosis and more effective irradiation. It is almost impossible to evaluate the relative importance of these factors statistically, as there are so many variables. For similar reasons one cannot draw accurate conclusions from a comparison of statistics, because one group of

17. Jackson, C. L.: The Treatment of Cancer of the Larynx, South. M. J. **34**:243 (March) 1941.

18. Regaud, C.; Coutard, H., and Hautant, A.: Rapport sur la Curie thérapie et la roentgenthérapie dans le cancer du larynx, Ann. d. mal. de l'oreille, du larynx **41**:967, 1922.

19. Blady, J. V., and Chamberlain, W. E.: Treatment of Cancer of the Larynx by Roentgen Irradiation, Am. J. Roentgenol. **51**:481 (April) 1944.

20. Four patients who died from causes other than cancer and who were free of recurrence are not included (table 2).

cases may contain a high percentage of advanced lesions and another a low percentage. Thus the report of Blady and Chamberlain [19] shows 64 per cent intrinsic lesions and 36 per cent extrinsic lesions, whereas the figures of the present report are exactly reversed—64 per cent extrinsic and 36 per cent intrinsic. Different criteria of classification and the difficulty of estimating the point of origin of the advanced lesion add to the complexity of the problem. One conclusion, however, can be drawn, namely, that intrinsic squamous carcinoma of the larynx is curable by irradiation, and the earlier it receives adequate treatment the greater is the curability.

CRITERIA FOR SELECTION OF TREATMENT

The choice between laryngectomy and irradiation is difficult. Despite the fact that most patients adjust themselves to loss of the larynx, irradiation is preferable if the chances of cure are equally good. The following criteria for the selection of treatment are based on the work at the Chicago Tumor Institute:

Operability.—Lesions which are extrinsic by origin or by extension are generally regarded as inoperable, and metastatic involvement of cervical nodes usually indicates inoperability. Any condition which indicates a short life expectancy, such as advanced age, cardiac disease, advanced arteriosclerosis, diabetes and pulmonary tuberculosis should influence the decision against laryngectomy. Obviously, the decision must be made in the light of the possibilities of irradiation. In borderline cases, especially when the patient asks for a chance of being cured without laryngectomy, it is well to know that subsequent radical operation is not seriously prejudiced by previous irradiation. Brunschwig [21] recently reported results of panlaryngectomy in 5 patients with advanced extrinsic carcinoma of the larynx in whom the disease was persistent after roentgen therapy. Excellent palliation was obtained in this group.

Microscopic Structure.—Many surgeons and pathologists believe that the more undifferentiated cancers have a worse surgical prognosis, and some clinicians are influenced by the histologic grade in their choice of treatment. Similar views are held on the relation between histologic grading and radiosensitivity. The view that the histologic structure is of minor importance in estimating radiosensitivity is shared by Kriegsmann,[22] Harris and Klemperer [23] and numerous others. Per-

21. Brunschwig, A.: Panlaryngectomy for Advanced Carcinoma of the Larynx, Surg., Gynec. & Obst. **76**:390 (April) 1943.

22. Kriegsmann: Demonstration von röntgenbestrahlten Kehlkopfkarzinomen, Hals-, Nasen- u. Ohrenarzt (Teil II) **44**:242, 1937.

23. Harris, W., and Klemperer, P.: Pathologic Differentiation Between Radiosensitive and Nonradiosensitive Malignant Neoplasms of the Larynx, Arch. Otolaryng. **28**:355 (Sept.) 1938.

sonal experience indicates that it is hazardous to draw conclusions from the histologic structure of a biopsy specimen except in a general way. Actually, it is not safe to render a dogmatic statement, on the strength of a biopsy, that the lesion is of high or low malignancy or that it is radioresistant or radiosensitive. It does not seem to be unusual for clinicians to base their choice of treatment on a report of the microscopic structure when the clinical picture clearly offers a contrary indication. To this general statement there are two exceptions: When the microscopic structure shows marked anaplasia, especially with the formation of spindle cells, the lesion is nearly always highly malignant and offers a bad prognosis regardless of whether a surgical procedure or irradition is used. The other exception is presented by the cancer in which the epithelial cells are uniformly small and transitional in type, especially when they show a convoluted plexiform arrangement. In such lesions one often finds interspersed islands of differentiated squamous elements with a tendency toward pearl formation. Cancers with this structure are generally radiosensitive and, if not too advanced, curable by proper irradiation. This structure is usually found in lesions originating in the false cords, the ventricles, the aryepiglottic folds and the epiglottis. The term "transitional cell carcinoma" is often used to describe cancers with this structure. Histologic grading when done by a pathologist especially experienced and skilled in this field has a value but can be hazardous unless interpreted broadly and in the light of the results of effective irradiation.

The view that squamous carcinoma is radioresistant has become entrenched in the literature. Every effort should be made to correct this fallacy, which is based on two errors: One is that squamous carcinoma is resistant to irradiation; the fact is that it is sensitive to maximum radiotherapy. The other error is that study of a single biopsy specimen gives a reliable histologic picture of the lesion; whereas there may be and frequently are other areas in the same tumor that are undifferentiated.

Clinical and Pathologic Factors in Relation to Radiosensitivity and Radiocurability.—The gross and the microscopic character of the lesion influence greatly its radiosensitivity and radiocurability. The site of origin is significant; thus carcinoma arising in one of the false cords or the epiglottis is generally radiosensitive even in the advanced stages, whereas carcinoma of a true cord is radiosensitive only before it has infiltrated and immobilized the underlying muscles. Generally speaking, papillary lesions are radiosensitive, infiltrating lesions relatively radioresistant.

(*a*) Radiosensitive Group: Lesions originating in the mucous membrane overlying loose connective tissue which lack the power to infiltrate the underlying muscle and which grow for long periods as movable noninfiltrating lesions are generally radiosensitive. This type sometimes forms bulky masses. It generally arises in cylindric cells and is undifferentiated. The regional lymph nodes which become the seat of metastases are comparatively soft and remain circumscribed and movable even when they have become large. In this respect they resemble the primary lesion. Carcinoma of this type is highly malignant and as a rule highly radiosensitive in spite of its extent or the presence of regional metastasis. Classic examples are cancers originating in the epiglottis, the false cords, the piriform fossa and the aryepiglottic fold.

(*b*) Radioresistant Group: Lesions arising in the mucous membrane overlying dense connective tissue and having a tendency to infiltrate the underlying muscle early, with early fixation of the surrounding structures, are comparatively radioresistant. Metastasis generally occurs later than in the former group and involves the regional lymph nodes in close proximity to the lesion. The lymph nodes are firm and tend toward early fixation in contradistinction to those involved by the other group, which are softer and tend to remain circumscribed and movable over long periods. Histologically, this type exhibits adult, differentiated morphologic features. In the early stages, when the growth is still superficial, it is radiosensitive and often radiocurable in spite of its structure. Once the underlying muscle has become invaded and fixed, the lesion becomes more radioresistant.

No sharp line of demarcation can be drawn between radiosensitive and radioresistant lesions. The quality of radiosensitivity varies in degree, and there is no accurate method of expressing the variation. This fact makes it exceedingly difficult to evaluate new methods of treatment, and the critical observer who effects a startling result with a new method of irradiation is haunted by the possibility that the result may have been due more to high radiosensitivity than to the special method employed.

Mobility of the laryngeal structures generally indicates that the lesion is early or, if more advanced, that it is papillary and not infiltrating. From the point of view of irradiation, such a lesion is radiosensitive and to a considerable degree radiocurable, the curability being directly related to the extent of involvement, the degree of malignancy, the general condition of the patient and the efficiency of the treatment.

Partial or complete fixation is often due to inflammation caused by secondary infection and not to carcinomatous invasion. Such fixation occurs especially after one or more biopsies. It generally begins to

diminish and disappears soon after irradiation is begun, and in cases of doubt this response is a useful sign in interpreting the cause of the fixation. Rapid increase in mobility also occurs after a small amount of irradiation when the lesion is highly radiosensitive. From a practical point of view the early and rapid response is an indication of radiosensitivity and probable radiocurability.

GENERAL COMMENT

In the majority of cases, cancer of the larynx begins on a true vocal cord, and hoarseness is an early symptom in 95 per cent of such cases. Cases in which an early lesion is limited to the middle of one cord yield about 80 per cent cures by laryngofissure and already offer at least an equal chance of cure by adequate irradiation, with restoration of the voice to normal. It is only too evident, therefore, that the problem of laryngeal cancer hinges mainly on early diagnosis. It is regrettable that in the present series an average period of nine months elapsed from the beginning of symptoms to the first laryngeal examination and an additional nine months before treatment was begun. As a result, only in 17 (15 per cent) of the 118 cases was the lesion limited to one cord.

Before 1922 surgical procedures constituted the only form of treatment for laryngeal cancer. Since then the technic and the effectiveness of irradiation have improved, and in recent years increasing numbers of operable lesions have for one reason or another been treated by irradiation with corresponding improvement in results. In 1931 I began to treat selected patients with operable carcinoma of the true cords by irradiation. At first irradiation was tried only when the patient refused laryngectomy or when there were general contraindications to operation. As the results improved, lesions of borderline operability were treated, and finally in 1938, when concentration radiotherapy was found effective, irradiation of operable intrinsic lesions was practiced by choice, provided the laryngeal structures were not completely fixed by the carcinoma.

The present procedure is to limit laryngectomy to cases of intrinsic cancer in which there is total fixation of the laryngeal structures and in which there are no local or general contraindications to surgical treatment, provided it is established that the fixation is due to carcinomatous invasion and not to inflammation. As the results of irradiation improve, the classification of operability becomes stricter. When the cords are still movable or only partly fixed, irradiation is chosen in preference to surgical removal regardless of the histologic grade or the extent of the lesion. In borderline cases irradiation may be tried when a patient asks for a chance to be cured by this method

with the understanding that laryngectomy may still be necessary. In this connection, the radiotherapeutic test may be used, and if the response is favorable, the treatment is completed. When the lesion appears to be unfavorable for radiotherapy and amenable to laryngectomy, the patient is urged to accept surgical treatment but if he refuses, he is given irradiation with the clear understanding that the chances of success are remote and that he will still probably be faced with laryngectomy. This course is justified because it is now established that previous correct irradiation does not seriously interfere with subsequent laryngectomy.

The selection of treatment is highly individual, and no rules can be applied to all cases. The attempt to choose the best treatment for each case is guided by the following criteria: (1) the operability of the lesion, intrinsic or extrinsic, and the presence or the absence of metastatic involvement of cervical lymph nodes; (2) the general condition of the patient, his life expectancy and the presence of serious organic disease; (3) the character of the lesion with respect to origin, extent, histogenesis, microscopic structure and more particularly the extent to which it has infiltrated and fixed the laryngeal structures; (4) the patient's temperament and his ability to adjust himself to laryngectomy and the extent to which his work and economic status are dependent on the normal use of the voice.

In the treatment of clearly operable cancer of the larynx the choice between laryngofissure and irradiation is not nearly so important as the choice between laryngectomy and irradiation. When a patient is faced with loss of the larynx and use of an artificial voice, he is confronted with a serious problem. The first question that occurs to him is what chances there are of cure without laryngectomy, and the responsibility of the laryngologist and the radiologist in advising him is evident. The surgical results are generally known, but the more recent results of irradiation are not yet well known.

It is interesting that as early as 1938 Jackson and Jackson [11] stated that there are growths classed as operable for which the patient is justified in choosing irradiation in preference to operation and predicted that the future would probably witness a progressive decrease in the relative number of laryngectomies. This prediction has proved to be true. Since this statement was made, significant progress has been achieved in the radiotherapy of laryngeal cancer, which has been reflected in the five year end results published from several clinics. It is therefore startling to read recent articles and discussions on cancer of the larynx in which irradiation either is not referred to or is mentioned as a palliative procedure for advanced and inoperable lesions. In view of the evidence at hand the failure to give serious consideration to the

results of modern radiotherapy is not to the best interests of the patient who is faced with the loss of his larynx. My associates and I agree with Jackson and Jackson [11] who stated in 1938 that they were decreasing the number of laryngectomies in proportion to the number of patients treated by irradiation.

CONCLUSIONS

Modern radiation therapy is an increasingly effective method of treatment for laryngeal cancer. Forty-two per cent five year cures and 39 per cent three year cures were obtained in a series of 118 unselected cases. Concentration radiotherapy has resulted in the curing of certain forms of cancer of the larynx hitherto regarded as incurable by irradiation. When the cords are freely movable or only partly fixed by the carcinoma, curability is high, but when they are completely fixed, cure is less common and laryngectomy is indicated. The most important result of this research is the demonstration that a group of patients with intrinsic squamous carcinoma of the larynx too advanced for laryngofissure and requiring total laryngectomy have been cured by irradiation. As the results of irradiation improve, the field for operation becomes smaller. Laryngectomy should be limited to intrinsic lesions with complete fixation of the cords occurring in good surgical subjects of good life expectancy. It is reasonable to expect that further improvements in the technic of irradiation and earlier diagnosis will further diminish the necessity of total laryngectomy.

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WARTIME LARYNGEAL INJURIES

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INJURIES of the larynx do not comprise the most frequent source of war casualties, but they do constitute one of the most serious forms of battle injury. This is true not only as to the immediate prognosis in regard to the loss of life but as to the future rehabilitation of the patient after the immediate crisis is past. The threatened advent of gas warfare would have sent the incidence of laryngeal injuries soaring, as the effect of poisonous gas on the larynx is well known and has been demonstrated not only from the experience of World War I but from accidents or improper handling of poisonous gases in World War II. As the battle casualties have mounted there has been a proportionate rise in laryngeal injuries, although the exact number will never be known as many of them have been recorded as injuries of the neck.

Laryngeal and tracheal injuries in peacetime are comparatively rare, the most common type being that perpetrated by the anatomically misguided would-be suicide who slits open his trachea, the cut often penetrating his esophagus, in a futile effort to end his life. Bailey [1] reported his experiences with 57 cases of cut throat. A review of the literature shows the trachea to be most susceptible to direct or indirect injury. Nach and Rothman [3] reported a series of 17 cases of laryngeal and tracheal injury, 11 tracheal and 6 laryngeal, extending over a period of ten years. Peacetime injuries of the larynx and the trachea in general have to do with stabs, wounds or cuts of the neck, a picture which differs from gunshot wounds of the neck. Perichondritis and chondritis of the laryngeal cartilages caused by gunshot and shrapnel display certain peculiarities that call for specific therapeutic measures differing from those of wounds of any other origin.

This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

1. Bailey, H.: Surgical Emergencies, ed. 4, Baltimore, Williams & Wilkins Company, 1940, pp. 580-589.

2. Footnote deleted by author.

3. Nach, R. L., and Rothman, M.: Injuries to Larynx and Trachea, Surg., Gynec. & Obst. **76**:614-622 (May) 1943.

Laryngeal injuries in World War I were associated with a high incidence of mortality, due to the inability to cope with complications. Various therapeutic agents, such as sulfonamide compounds, penicillin and plasma, were unheard of, and physicians with bronchoscopic experience were rare. Tracheotomized patients were termed "whistlers," and even the changing of tracheotomy tubes was a major procedure, as many of the physicians were unfamiliar with such devices.

Laryngeal injuries may be classified in various ways. Bailey divided laryngotracheal injuries into (1) those situated above the hyoid bone, (2) wounds of the thyroid cartilage, (3) wounds occurring above, through or below the cricoid cartilage and (4) wounds of the trachea. This classification is not applicable to wartime injuries because of the more extensive trauma brought about by shrapnel and various other types of projectiles. Other factors, such as gaseous and thermal agents, are not usually associated with civilian injuries. Laryngeal injuries may be classified as direct, indirect, gaseous and thermal.

Direct injury of the larynx is by far the most common source of laryngeal casualties. It is usually brought about by shrapnel, a bullet or a blow. Shrapnel injury of the larynx is by far the most serious variety, as a ragged piece of metal has a tendency to perforate the laryngeal box and destroy large portions of the surrounding tissue. Shrapnel has a tendency to cause multiple wounds, thus putting a greater strain on the patient's vitality and thereby increasing the mortality. The bullet in several instances in our series has shown a tendency to deflect off the thyroid cartilage, thus lessening the injury to the larynx. A bullet when it does enter the lumen of the larynx has a tendency to leave a much cleaner wound than shrapnel does. Laryngeal injuries increase as education in Judo and other similar methods of hand to hand combat has demonstrated the vulnerability of the larynx to blows in rendering an enemy *hors de combat*. Fracture of the larynx may be accomplished by forcibly compressing it against the vertebral column. Indirect injury of the larynx is usually associated with some trauma that impairs the nerve supply. It may be due to a head injury involving the central pathways or to injury of the superior or the recurrent laryngeal nerves in their peripheral course in the neck.

Poisonous gases, as is well known, usually cause ulceration of the mucous membrane of the larynx, perichondritis, abscess and frequently healing with laryngeal stenosis. The use of poisonous gases was restricted in the war, and the varieties of gases have not been revealed.

Thermal trauma is not common, but one of the most frequent sources of laryngeal damage in our series of cases was the unfortunate and ill advised use of electric cautery on laryngeal lesions before the patients had been brought to this hospital. The inhalation of intense

heat associated with the use of flame throwers was probably the most important factor in increasing injuries of this type. Kernan [4] found that the symptoms of laryngeal injuries due to heat develop slowly.

The various types of laryngeal injuries that pass through a large service hospital not only produce some bizarre pictures but reflect in some instances poor surgical judgment and ignorance of the management of laryngeal traumas and their complications. The matter of referring the patient to a competent speech pathologist for laryngeal reeducation is all too frequently overlooked after the maximum amount of anatomic repair and physiologic function has been achieved.

From our series of 43 cases some of the most representative types of laryngeal injuries are presented. It is of interest to note that several of these laryngeal injuries, despite the fact that they were caused by traumas usually associated with war, occurred many thousands of miles from the nearest battle zone.

DIRECT TRAUMA

CASE 1.—The patient was struck in the right side of the neck with a bullet of 25 mm. caliber. The bullet glanced off the thyroid cartilage but damaged the cricothyroid membrane and passed out of the neck. The patient had difficulty in breathing for several days and spat up small quantities of blood for a week. Total aphonia was present for two weeks. The voice returned, but was almost unintelligible, and there was great shortness of breath after only mild exertion. When the patient arrived at this hospital, direct laryngoscopy revealed a thin web in the anterior commissure and stenosis of the larynx at the level of the cricothyroid membrane. The web was incised along the border of the left true cord and the larynx dilated. During the dilation the patient was sent to a speech pathologist for reeducation in phonation as a tendency to phonate incorrectly had developed since his injury, to compensate for the injury. Progress was excellent. The patient returned to full duty.

CASE 2.—The patient was in the vicinity of an explosion of depth bombs. Fragments of the shell caused a perforating wound of the larynx in the region of the cricothyroid membrane. A small piece of steel also entered the right eye. A tracheotomy tube was inserted through the wound in the larynx, thus establishing a patent airway at the scene of the accident. This undoubtedly saved the patient's life. He was brought into a naval hospital in shock and received 2 units of plasma. An elective tracheotomy was done between the second and the third tracheal ring, and the wound in the larynx was closed. When the patient's condition was considered favorable, direct laryngoscopy revealed a web occupying the anterior half of the glottic space. The upper part of the trachea was slightly stenosed. The laryngeal web was incised at this time and the larynx dilated at four day intervals. The patient improved rapidly, and plastic repair of the trachea was done. This patient was discharged from service because of impaired vision.

CASE 3 (figs. 1 and 2).—The patient received a shrapnel wound which pierced the neck from the left posterior cervical region to the right anterior cervical

4. Kernan, J. D.: Traumatic and Therapeutic Injuries of the Larynx, Laryngoscope **51**:292-295 (March) 1941.

region. A large part of the cervical part of the esophagus was severed. At the field hospital, some of the larger vessels on the left side of the neck were ligated, and a tracheotomy tube was inserted into the wound at the level of the cricothyroid membrane. Several units of plasma was administered, and two whole blood transfusions were given at the field hospital. A Levine tube was passed, and the patient was fed by this means. A pharyngeal fistula was discovered, and one week later gastrostomy was performed. The patient was evacuated to the mainland and on entering this hospital was breathing through a tracheotomy tube inserted in the cricothyroid membrane. A permanent tracheotomy opening was made at the level of the second tracheal ring. After a careful examination

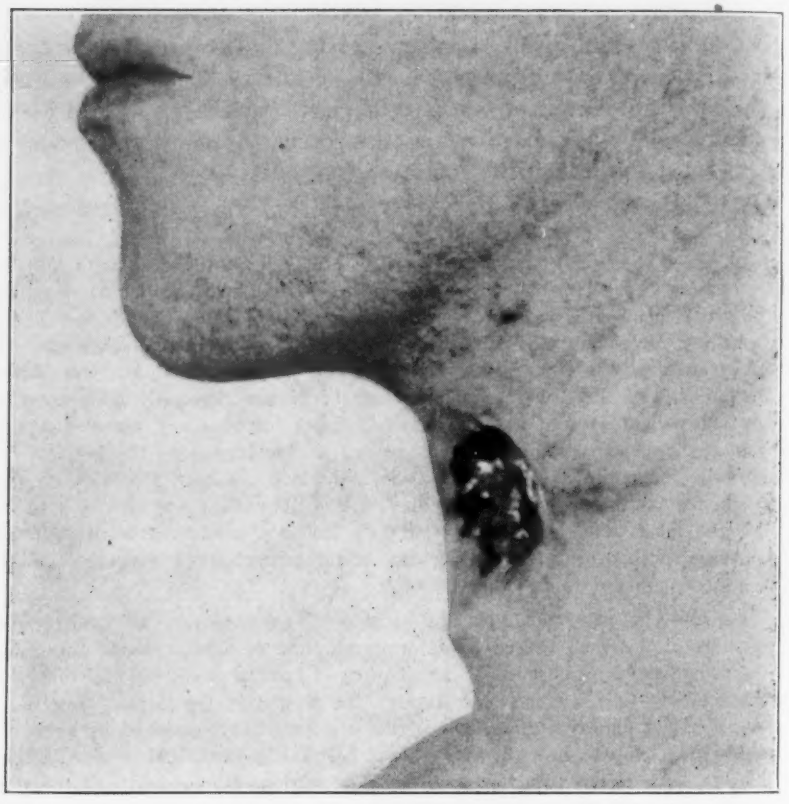

Fig. 1.—Injury of the larynx, side view.

it was decided that as so much of the laryngeal box had been avulsed and there was in addition esophageal fistula, laryngectomy was the procedure of choice. This was performed and the esophageal fistula closed. The patient made an uneventful recovery. The gastrostomy opening was closed after several fluoroscopic inspections with barium sulfate had demonstrated the integrity of the esophagus. The patient was provided with an artificial larynx and in addition was given instruction in the technic of buccal-esophageal speech.

CASE 4 (fig. 3).—The patient was wounded while tearing down a 20 mm. shell; the fragments struck on the anterior lateral surface of the neck, glancing off the

thyroid cartilage and burrowing beneath the sternocleidomastoid muscle. When admitted to the hospital, the patient was in profound shock, and 2 units of plasma was administered immediately. The patient was taken to the department of surgery where with direct laryngoscopy the intralaryngeal picture was evaluated, particularly with respect to the patency of the airway. Direct laryngoscopy revealed a marked swelling on the right side of the epiglottis. The right piriform sinus was filled with debris and bloody secretion. Both arytenoids were edematous, especially on the right side. The whole larynx showed edema, but there appeared to be sufficient airway, so that tracheotomy was not performed. Feeding by tube

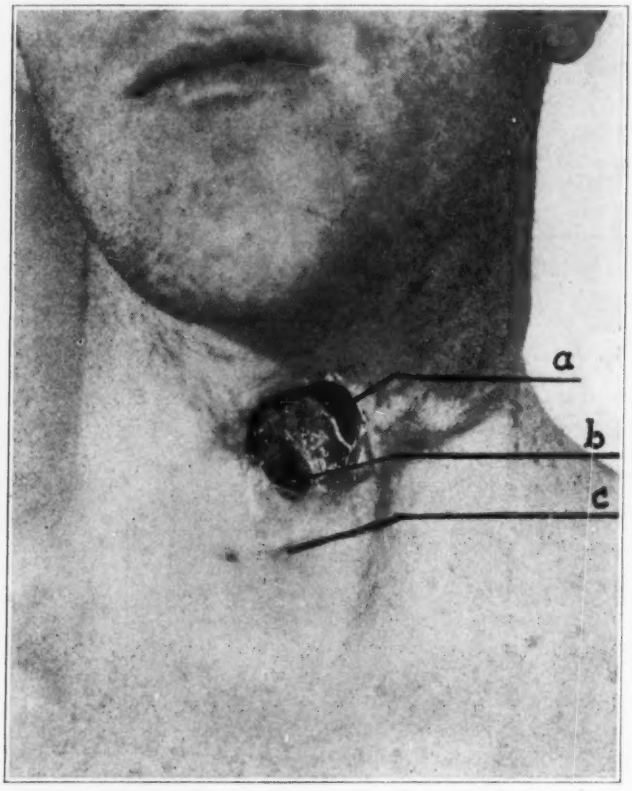

Fig. 2.—Front view of the wound shown in figure 1: (*a*) hypopharyngeal fistula; (*b*) tracheotomy; (*c*) thyroid cartilage.

was done for three days, and fluids were given intravenously. Despite the fact that the patient had little difficulty in breathing, an emergency tracheotomy set was kept at the bedside. Routine tetanic prophylaxis was administered. Direct laryngoscopy repeated in a week revealed paralysis of the right vocal cord due to injury of the right recurrent laryngeal nerve. Meantime Horner's syndrome developed on the right side. It was decided to remove the shrapnel from the neck, and an incision was made over the sternocleidomastoid muscle. The incision was deepened by blunt dissection, and with the aid of a biplane fluoroscope the shrapnel was located beneath the carotid sheath at the level of the sixth cervical

vertebra. The shrapnel was removed, and the patient had an uneventful recovery. He was returned to limited duty with the following note: "The patient has paralysis of the right true cord and fixation of the arytenoid, which can be considered permanent but in no way incapacitating. Vocal function will improve with formation of a fibrous band and compensation of the left true cord." The patient was discharged to duty two months after the original injury.

CASE 5.—The patient was wounded July 28 by shrapnel, which entered the left side of the neck about the level of the hyoid bone and passed downward and inward to lodge in the right side of the neck near the piriform sinus. This was accompanied by severe dyspnea, and emergency tracheotomy was done on the beach a hundred yards from the foxhole where he was wounded. The patient was flown to a base hospital, and 100,000 units of penicillin was administered.

Fig. 3.—*A*, shrapnel that was lodged in the right side of the neck of the patient (*B*), who is shown after removal of the shrapnel.

Direct laryngoscopy showed marked edema of the larynx. The fragment could be seen buried in the right thyroid cartilage posteriorly and laterally and piercing into the piriform sinus of that side. The fragment became dislodged during manipulation and passed into the esophagus. A sizable fistula was present between the larynx and the piriform sinus requiring feeding through a Levine tube. The patient received a total dose of 5,000,000 units of penicillin. The edema subsided and the fistula closed, permitting normal deglutition. The arytenoids were partly fixed, especially on the left side. The restriction of motion of the cords was such that the tracheotomy tube could not be removed.

As the patient's general health progressed, dilations were tried but were unsuccessful He was removed to this hospital, where examination revealed

bilateral paralysis of the recurrent laryngeal nerves, with cords fixed in the intermediate position. A Kelly-King procedure enabled the patient to breathe without the aid of a tracheotomy tube.

CASE 6.—In a period of depression the patient attempted to cut his throat with a razor. After he arrived in the hospital, examination revealed a gash at the level of the cricothyroid membrane. The wound was closed, and as the patient had lost a considerable amount of blood, plasma and whole blood transfusions were administered. He was given intravenous feedings for several days. Some time later he returned to this hospital, complaining of shortness of breath on exertion and difficulty in phonation. Laryngeal examination revealed a thick web in the anterior commissure, which occupied about one third of the glottic opening. The web was incised along the free border of the right true cord and removed. The larynx was dilated at weekly intervals. The patient was sent to a speech pathologist for training.

CASE 7.—The patient was thrown violently against the rail when his ship collided with another vessel. The force of the blow was received mainly across the larynx. He complained of sore throat and some aphonia for several weeks. Later his voice returned to almost normal. One year later, after a drinking party, the patient awoke with complete aphonia. He was sent to the psychiatrist with a diagnosis of malingering. After several futile efforts to get the patient to speak under nacrosynthesis, he was sent to the department of laryngology. Direct examination showed a swelling of the false cords on the left side. The left true cord was almost absent, being replaced by a small fibrous band. There apparently had been an ulcerative process on the left side of the larynx. The patient's attempt to phonate revealed a purselike effect on his false cords. He was sent to the speech pathologist and made excellent progress in achieving an improvement in his speech.

CASE 8.—A Wave was riding in a motor car which struck a telephone pole. She was removed from the wreck and brought into the hospital but was pronounced dead on arrival. An autopsy was performed, but the cause of death could not be immediately ascertained. The undertaker, while in the process of embalming the body, felt a hard mass in the hypopharynx. The pathologist was again called and on opening the hypopharynx found a piece of the gear transfixed just below the base of the tongue, compressing the epiglottis against the larynx, thus blocking the glottic chink. Death was due to suffocation.

THERMAL TRAUMA

CASE 9.—The patient became hoarse in late 1943 and turned into a sick bay. Indirect examination of the larynx revealed a papilloma. Fulguration removed the papilloma, but several days later the patient complained of tenderness in the region of the thyroid cartilage. Perichondritis subsequently developed, and a portion of the thyroid cartilage sloughed out. A tracheotomy tube was inserted into this opening, and the patient was transferred to this hospital in poor condition. After a thorough examination, a new tracheotomy opening was made between the second and the third tracheal ring. Incision and drainage of the thyroid cartilage were carried out, at which time many pieces of necrotic cartilage were removed. The wound was dusted with sulfanilamide powder. Smear revealed the presence of staphylococci, and appropriate sulfanilamide therapy was instituted. Direct laryngoscopy revealed a large papilloma attached to the right cord. Two weeks later by direct laryngoscopy the papilloma was removed. Two

months later the tracheotomy tube was removed, and the patient returned to duty with a fair speaking voice.

INDIRECT TRAUMA

CASE 10.—The patient swallowed a chicken bone which perforated the esophagus. Direct examination thirty-six hours later disclosed no foreign body. However, a small abrasive area representing a perforation of the esophagus was present. Emphysema followed this procedure but subsided in twenty-four hours. Three days later a mediastinal abscess formed and was drained by cervical mediastinotomy. After an afebrile course of several weeks, the patient's temperature again rose to 101 F. A study made with iodized poppyseed oil 40 per cent revealed a fistula of the posterior wall of the esophagus which curved around it and passed between the esophagus and the larynx. The abscess was drained and the fistula closed. The patient was fed by means of a Levine tube. After two weeks he began to have laryngeal pain and was having difficulty in breathing. A diagnosis of perichondritis was made, and tracheotomy was performed. Sulfanilamide was administered, and blood transfusions were made. When the perichondritis subsided, direct examination of the larynx revealed subglottic stenosis and web formation. The web was incised and the larynx subsequently dilated at repeated intervals. The patient was returned to duty with some impairment of the phonatory function and slight difficulty in breathing on exertion.

CASE 11.—The patient was exposed to chlorosulfonic acid gas in November 1943 when a drum of this gas broke open in the hold of his ship, where he was working. He was removed in an unconscious state and sent to a hospital. Pneumonitis and ulcerative laryngitis developed. On recovery from the pneumonitis the patient still complained of cough and hoarseness, as well as of shortness of breath on exertion. Direct examination of the larynx showed both cords denuded of normal epithelium. There was also a thick web anteriorly between the true cords with partial stenosis of the larynx anteriorly subglottically. The web was incised along the free border of the left true cord, and the larynx was subsequently dilated several times. The patient returned to limited shore duty with a good voice.

COMMENT

Treatment of laryngeal injuries may be divided into three phases: the first or immediate phase transpires at the time of injury and is usually done under field conditions. In many instances an injury of the larynx is accompanied by profound shock out of all proportion to the apparent injury. The immediate concern in regard to a laryngeal injury is directed to maintain the patency of the airway. An external injury of the larynx and the trachea which does not rupture into the lumen will in many instances cause swelling and edema of the soft structures of the laryngeal box, with suffocation resulting from interference with the airway. Prompt tracheotomy in such instances cannot be too strongly stressed. Even if sufficient airway is maintained to sustain life, the strain of forced respiration may tax the cardiac mechanism to such an extent that myocardial damage may be superimposed on the already lowered resistance.

A tracheotomy performed under field conditions combines all the hazards and the stress and strain of a peacetime emergency tracheotomy

with the many unavoidable factors of war conditions added. These factors are: multiple injuries, weather conditions and that not too small factor of the operator's own personal safety under enemy shellfire. However, the basic principles of the emergency tracheotomy remain the same. Perhaps one of the greatest pitfalls is the failure to keep the incision in the midline of the neck, due to inability to keep the trachea centered between the thumb and the forefinger, and too much unilateral traction of the skin, which pulls the incision to one side of the midline. These mistakes not only slow down the procedure, because of the difficulty in finding the trachea, but may lead to fatal complications if the trachea is by-passed and the tissue spaces of the neck are opened to infection. A false entrance may be made into the esophagus.

In the field, if the larynx or the trachea has been penetrated, a tube may be inserted into the wound as a temporary life-saving measure, the attendant being sure that the airway is not blocked by debris from the wound. Sedatives, such as morphine, must be used sparingly and in general are contraindicated. Vessels should be ligated, particularly with regard to blood gaining entrance into the trachea. The wound should not be sutured tightly because of the danger of emphysema. The use of plasma to combat shock should be instituted. Sulfanilamide powder should be placed in the wound. The patient should be tagged with a written order that nothing be given by mouth as in a significant percentage of cases in our series the esophagus was also penetrated. Intravenously injected fluids into which sulfanilamide has been introduced will be helpful postoperatively.

The second stage of treatment of the laryngeal injury may be said to last until the maximum amount of physiologic function and anatomic repair has been accomplished. Surgical treatment of laryngeal injuries is varied, each patient presenting a different technical problem that must be worked out by the operator's own ingenuity.

The first step, which must be carried out before any surgical plan can be fostered, is direct laryngoscopy, in which the extent of the damage to the larynx is evaluated. While a Jackson type of laryngoscope is preferable, a Flagg electrically lighted laryngeal speculum will give excellent exposure of the larynx and may be easily carried as part of the equipment of a field hospital. In direct laryngostomy, the position of the head is of utmost importance. Excellent flexion of the head may be accomplished in the absence of trained head holders if the patient's head is placed in extreme flexion in the operator's lap, the shoulders remaining flat on the table.

One of the first procedures to be considered is elective tracheotomy. This procedure is necessary in cases in which a tube has been hurriedly inserted into a wound in the larynx or the trachea. Elective tracheotomy is also necessary in cases in which the emergency field trache-

otomy has been poorly placed or in which, owing to future treatment, tracheotomy is necessary. Intubation with a Mosher type of life-saving tube may be carried out in some cases. Judgment as to whether tracheotomy is necessary in the presence of an intact larynx must be tempered by the knowledge that anatomically the lumen of the larynx is not much larger than is required for respiration. Even a small amount of edema puts a strain on the respiratory and cardiac systems, and the presence of only a moderate amount of blockage is necessary to cause asphyxia. When tracheotomy has been performed, explicit instructions should be left that the outside tube should not be changed for at least four days except in case of blockage and then the procedure should preferably be performed in an operating room, with the Trousseau type of laryngeal dilator at hand together with another tube of the same type, sterilized and ready for introduction.

The most frequent complication of laryngeal injuries is perichondritis. There is wide divergence of opinion as to the handling of this complication. It is generally agreed that if the perichondrium of the laryngeal cartilage has not been injured, recovery is rapid and distortion of the larynx is usually nil. If, however, the perichondrium has been injured extensively, as frequently happens in war traumas, there are usually perichondritis, abscess formation and necrosis, with resultant stenosis of the larynx.

Russian authors [5] have reported many cases of wartime laryngeal injuries, stating that gunshot perichondritis runs a sluggish course with a very slight general systemic reaction. The blood, the temperature and the sedimentation rate remain close to normal. In many of their series of cases as late as two years after laryngostomy, in the face of normal temperature and absence of laryngeal tenderness, suppurative foci have been found. Therefore they recommend surgical intervention at an early stage in gunshot lesion of the larynx with a view to not only preserving as much as possible of the skeleton of the larynx but avoiding sepsis due to infected tissue adhering to the soft tissue. They are opposed to the usual waiting six months after all inflammatory conditions have subsided for laryngeal repair. Other articles have appeared in the literature on the subject of laryngeal injuries, notably those by Evans,[6] Lewis,[7] Huizinga and Siemens,[8]

5. Trutner, V.: Wounds and Injuries of the Larynx, Arch. Otolaryng. **36**: 629-631 (Nov.) 1942.

6. Evans, C.: Tratment of Wounds and Injuries, M. Press **209**:91-93 (Feb. 10) 1943.

7. Lewis, R. S.: Wounds of Neck and Larynx, Lancet **1**:781-784 (June 17) 1944.

8. Huizinga, E., and Siemens, B. W. L.: Scalding of the Larynx in Children, Arch. f. Ohren-, Nasen- u. Kehlkopfh. **148**:182-187, 1940.

Rao,[9] Kuchinka,[10] Perwitzschky,[11] Despons,[12] Falk,[13] Gouvea,[14] Bruggeman,[15] Reeves [16] and Lumsden.[17] The Jacksons [18] expressed the belief that the wound should not be explored until there is positive evidence of suppuration. Debridement within the larynx is contraindicated, as almost any surviving tissue near the larynx may help in building anterior support of the pharynx. The more conservative type of surgical procedure was followed in our series of cases with excellent results. Roentgen and laminographic studies are helpful in following the progress of cartilaginous involvement with or without abscess formation.

Pneumonitis frequently follows laryngeal injuries, resulting from aspiration of blood and debris. There is impairment of the cilia of the bronchi and the trachea, and great difficulty is experienced in expelling the thick mucus. Bronchial drainage obtained by endoscopic technic is a life-saving measure. In the case of tracheotomy frequent aspiration with a rubber catheter should be carried out under aseptic precautions.

Emphysema is a frequent complication, as air gains entrance into the soft tissue spaces. In general, this does not offer a too serious prognosis but does cause much annoyance to both patient and doctor. Its avoidance is sought by not dissecting the peritracheal structures and not suturing the wound too tightly.

Infection and mediastinitis are a feared complication and must be guarded against with the greatest care. The advent of mediastinitis is proclaimed by leukocytosis with a marked increase of polymorphonuclear cells. There is a rise of temperature, and the patient begins to

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13. Falk, P.: Therapy of War Injuries of the Larynx, Med. Welt **14**:81-84 (Jan. 27) 1940.

14. Gouvea, A.: Complete Left Recurrent Laryngeal Paralysis Produced by Cervical Hematoma After Deep Bullet Wound of Neck, Rev. méd. brasil. **11**:113-116 (Aug.) 1941.

15. Bruggeman, A.: War Wounds and Their Therapy, Therap. d. Gegenw. **83**: 313-318 (Sept.) 1942.

16. Reeves, B.: Penetrating Shell Wounds of the Neck Involving Larynx, J. Laryng. & Otol. **58**:327-330 (Aug.) 1943.

17. Lumsden, R. B.: Wound or Injuries Due to Explosion, J. Laryng. & Otol. **57**:385-386 (Aug.) 1942.

18. Jackson, C., and Jackson, C. L.: Wounds and Injuries of the Larynx, Indust. Med. **8**:474-476 (Nov.) 1939; Laryngeal Trauma, Arch. Otolaryng. **38**: 413-425 (Nov.) 1943.

complain of difficulty in breathing and swallowing. There is a swelling of the neck on the affected side, with tenderness to pressure. The rapidity of the development of the infection depends on the virulence of the infecting organism and the resistance of the patient. Needless opening of intact fascial sheaths in debridement of cervical wounds must be avoided. Penicillin should be given and cervical mediastinectomy performed when formation of a cervical abscess takes place.

Tracheal-esophageal fistulas are common in laryngeal traumas, as a perforating wound of the larynx frequently penetrates the esophagus. The integrity of the esophagus should be ascertained, as the presence of a bronchial-esophageal fistula may lead to fatal complications. If the esophagus has been perforated, gastrostomy is preferable to an indwelling catheter inasmuch as the latter may cause decubitus of the mucosa behind the cricoid if left in place over any length of time. Saliva entering the wound from the hypopharynx is a factor in infections.

An injury of the esophagus should be attended to as soon as the condition of the patient permits further surgical treatment. The esophagus may be closed by using interrupted chromic catgut sutures. If the esophagus has been completely severed, the technic described by Scott may be followed. This consists of the use of interrupted chromic sutures, the posterior muscular walls being united first, and the posterior mucous membrane next, the knots being tied on the inside of the lumen. The anterior mucous membrane is next sutured, the knots being tied externally to the lumen. The anterior coat may then be sutured.

Stenosis and web formation frequently follow laryngeal injury. If there is complete stenosis of the larynx, laryngostomy may be performed, the larynx laid open and the cicatricial tissue removed, care being taken not to damage the vocal cords if these are present. If the cricoid and the upper part of the trachea are stenosed, an elastic dilation tube is placed in the groove of the larynx and tied to the tracheotomy tube. Stenosis of the upper part of the larynx may be treated by the use of core molds, which help to shape the interior of the larynx. Von Schmiegelow has designed a rubber dilator which may be left in place without the necessity of removal, and thus the amount of pain is lessened. Vitallium and tantalum dilators have been used recently with success.

When the laryngeal box has been badly damaged with loss of tissue, distortion of the anatomic structures and permanent loss of vocal function, laryngectomy may be the operation of choice.

Webs frequently result from laryngeal wounds. In some instances in our series the web was so extensive as to cause marked impairment of respiration. In all the cases in our series in which there was web formation there was marked vocal impairment. The web was incised

along the free border of one vocal cord. Another incision was made along the opposite cord four days later, followed by frequent dilations of the larynx.

The subject of rehabilitation is too often overlooked in the plan of treatment. The average surgeon forgets that the larynx has two physiologic functions, one of respiration and one of phonation. The latter is frequently minimized. Patients with laryngeal injury all too often learn to speak incorrectly and despite anatomic correction of the laryngeal injury fail to get the maximum benefits that they are entitled to expect. The rate of recovery in laryngeal injuries is much slower when there is improper breathing and phonation. When laryngectomy has been performed, an esophageal voice must be developed. It is remarkable to note the psychogenic reactions which will develop in a patient who is left with a noticeable vocal impairment. The profound depression with suicidal tendency that follows a loss of voice as a result of total laryngectomy is well known. Recordings of the voice were kept in a number of instances so the patient could observe his progress. Speech proficiency in laryngeal injury is something that cannot be accomplished in one or two lessons. The maximum benefits of this instruction cannot be attained by the average person in less than two months. Several hours daily are required in classes plus painstaking practice at home. The successful processing of the patient in vocal rehabilitation as an adjunct to laryngeal surgical procedures was responsible for our ability to return several of these patients to useful duty.

SUMMARY

It is difficult to ascertain the number of laryngeal casualties. Statistics are difficult to obtain, and the anatomic description of death in the field frequently contains a description of multiple wounds without specifying the larynx as a site of injury. Deaths at sea are likewise not within the realm of classification.

We have chosen representative cases to illustrate the problems and the methods employed in meeting them. Similar traumatic influences will still confront the laryngologists after World War II, and their management should be one of general interest.

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CHRONIC DACRYOCYSTITIS: ITS TRANSAPERTURAL APPROACH

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THE management of chronic dacryocystitis has been for many years a controversial topic among ophthalmologists and rhinologists. The problem has been not only how to treat this affliction but who should treat it. A review of the subject may help to clear up some of the moot points.

In most instances dacryocystitis in itself is not a serious disease except for the constant epiphora which plagues the patient. However, it is considered a potent cause of corneal ulcers. Moreover, when an operation on the eye is contemplated as for extraction of a cataract or for glaucoma, coexisting dacryocystitis becomes an additional problem to the ophthalmic surgeon and must be eradicated first, as a prophylactic measure.

DIAGNOSIS

The diagnosis of this condition is apparent when the patient presents himself with a history of lacrimation that has been persistent for a varying length of time. The secretion may be watery, mucoid or mucopurulent. The possibility of syphilis, tuberculosis, actinomycosis or Mikulicz' disease should be considered.

It is necessary to point out that tumors do occur in the sac. Penman and Wolff [1] collected 64 cases recorded in the literature: adenoma, 1; carcinoma, 24; endothelioma, 4; fibroma, 2; lymphoma, 5; papilloma, 7; plasmocytoma, 1; sarcoma, 20.

Radiography as a Diagnostic Aid.—Several authors have suggested the use of a radiopaque substance by means of which the lacrimal apparatus may be visualized and the exact nature of its pathologic process demonstrated. Campbell, Carter and Doub [2] injected paste of bismuth, N. F., into the lacrimal sac.

Read before the Section of Otolaryngology of the New York Academy of Medicine, March 21, 1945.

1. Penman, G. G., and Wolff, E.: Primary Tumors of the Lacrimal Sac, Lancet **1**:1325-1328 (June 11) 1938.

2. Campbell, D. M.; Carter, J. M., and Doub, H.: A Method for Roentgenray Demonstration of the Nasolacrimal Passageways, Am. J. Roentgenol. **9**: 381-387 (June) 1922.

Hourn [3] described a rather complicated method of visualizing the lacrimal duct by means of iodized oil, and concluded: "I realize there are technical difficulties and obstacles that may make impractical the universal use of the intranasal film and the use of the nasal ostium for injections and probing of the lacrimal duct, but I hope it may be of useful service where indicated."

Roentgen visualization of the lacrimal apparatus may be of some scientific value but I doubt that it is of practical importance. The introduction of a bismuth compound into an already damaged duct may impede an early postoperative recovery.

The prognosis regarding spontaneous cure is poor if the infection is well established.

MECHANISM OF LACRIMATION

According to MacMillan,[4] the lacrimal glands are supplied by the fifth and seventh cranial nerves and by the sympathetic nerve which is derived from the carotid plexus accompanying the lacrimal artery. Irritation of any of these nerves causes excessive tearing.

Under normal conditions most of the fluid excreted by the lacrimal glands for the purpose of moistening the eyeball evaporates, but some of it finds its way into the lacrimal apparatus. When the glands are irritated by outside factors, such as fumes, cold, wind, foreign bodies in the cornea or in the conjunctiva, or when emotional distress occurs, the tears overflow.

When the sac is involved in gross pathologic changes, it not only ceases to function as a means of driving the tears through the natural channel but in addition reflexly causes increased tearing.

In cases of paralysis of the seventh nerve,[5] the resulting inaction of the orbicularis muscle removes the natural pumping action of this muscle. Consequently tears are not propelled or sucked into the lacrimal sac and down the nasal duct.

ETIOLOGIC AND PATHOLOGIC ASPECTS

Chronic dacryocystitis may be either congenital or acquired. It is usually caused by a stricture in the lacrimal duct secondary to inflammation of the mucous membranes of the nose by sinusitis or by trauma of any kind. A tumor may block the lacrimal passage. Chronic dacryocystitis is more frequent in females and is more prevalent in the poorer classes. Nasal deformities, particularly saddle nose, are frequent causes. It is more common in the aged, though children are not immune.

3. Hourn, G. E.: X-Ray Visualization of Naso-Lacrimal Duct, Ann. Otol., Rhin. & Laryng. **46**:962-975 (Dec.) 1937.

4. MacMillan, J. A.: Prevention and Treatment of Lachrymation, Canad. M. A. J. **44**:284-288 (March) 1941.

5. Doyne, P. G.: Watery Eyes, Practitioner **146**:151-153 (March) 1941.

Rarely it occurs in the newborn; this is thought to be the result of delayed perforation of the thin diaphragm of mucous membrane which closes the lower end of the nasolacrimal passage in the fetus; as a result of disintegration of the gelatinous contents of the tear sac of the infant, an inflammation takes place. Tuberculosis, syphilis and actinomycosis are rare etiologic factors.

Polack [6] removed the sac in 75 cases, in which it showed the following pathologic conditions: (1) damage of the epithelial covering; (2) infiltration of the mucous and submucous layers; (3) formation of scar tissue.

TREATMENT

Treatment of chronic dacryocystitis may be divided into (*a*) conservative and (*b*) surgical. The commonly accepted conservative measures are irrigation and probing of the lacrimal duct. Some advocate (1) electrocoagulation,[7] (2) surgical diathermy,[8] (3) copper ionization,[9] (4) use of metal retention probes [10] and (5) the silk cord method.[11]

When conservative measures fail (Hughes, Guy and Bogart [12] are convinced that if two or three probings failed repetition was futile), the ophthalmologist frequently resorts to dacryocystectomy. The indications for this surgical intervention according to Fuchs [13] are:

> . . . (1) when it is a matter of concern to protect the eyeball from dangers such as corneal ulcers which threaten it from virulent organisms in the tear duct secretion (2) before any surgery on the eyeball itself is contemplated (3) when the patient, for economic reasons, cannot submit to prolonged treatments.

In using any surgical procedure the surgeon aims either to eliminate a diseased organ and thus eradicate the symptoms or—and this is

6. Polack, B. L.: On the Pathology and Radical Surgery of Dacryocystitis, abstracted, Russk. ophth. j., November-December 1930; cited by Brown, E. V. L.; Bothman, L.; Shambaugh, G. E., and Hagens, E. W.: The Eye, Ear, Nose and Throat, Chicago, The Year Book Publishers, Inc., 1931, p. 14.

7. Morgenstern, D. J.: Intranasal Drainage for Cure of Tear Sac Infection, Arch. Ophth. **27**:733-745 (April) 1942; Am. J. Ophth. **25**:982 (Aug.) 1942.

8. MacGillivray, A. M.: Infantile Dacryocystitis Treated by Surgical Diathermy, Brit. J. Ophth. **23**:630-631 (Sept.) 1939.

9. Hilgartner, H. L., Jr., and Hilgartner, H. L., Sr.: Use of Copper Ionization in Treatment of Chronic Stenosis of Lacrimal Duct, Am. J. Ophth. **18**:54 (Jan.) 1935.

10. Sitchew, A. I.: Treatment of Purulent Dacryocystitis by Metal Retention Probes, abstracted, Arch. de oftal. **8**:648, 1930.

11. Sander-Larsen, S.: Silkensnorsbehandlung af taarevejsstriktur, Hospitalstid. (Oftal. selsk. forh.) **74**:35-38 (Oct. 29) 1931.

12. Hughes, W. L.; Guy, L. P., and Bogart, D. W.: Dacryocystorhinostomy, Surg., Gynec. & Obst. **73**:375-380 (Sept.) 1941.

13. Fuchs, E.: Diseases of the Eye, ed. 10, Philadelphia, J. B. Lippincott Company, 1932, p. 134.

ideal—to restore the organ to its normal functions. Extirpation of the sac does not achieve either of these objectives. The authorities on the subject have frankly admitted that in most instances epiphora persists after operation, especially when the eye is exposed to cold or wind. To quote Posey:[14]

> . . . Removal of the sac gets rid of a diseased structure, but it does not restore the lacrimal apparatus to a normal condition. Indeed, it annihilates for all time the excretory mechanism. Any operation, therefore, which restores the mucous membrane of the sac to a healthy condition and establishes free and permanent drainage should be regarded with favor and receive proper trial in selected cases.

Gilbert[15] investigated the problem of persistence of the epiphora after cystectomy, analyzing observations on 45 patients. These presented no operative or postoperative complications, such as fistula or any form of suppuration, leaving as a basis of his report examples of a clean, healed site of complete removal of the sac. Among patients were some operated on for mucocele and stenosis following abscess. In the whole group of 45 patients there was not a single patient free from epiphora one and a half years after cystectomy. In about 50 per cent the epiphora persisted for two to five years. In the majority the epiphora was severe and was aggravated by wind, cold and prolonged use of the eyes. Most of the patients denied relief from tearing and were willing to undergo further surgical treatment for cure. These results indicate that cystectomy, while of great value if a source of infection is to be removed, still leaves troublesome epiphora in most instances.

There are other disadvantages in the procedure. Besides not being entirely effectual, external extirpation of the lacrimal sac involves some degree of danger. Kayser[16] reported that in 1 instance a profuse hemorrhage occurred in a 65 year old patient in the course of operation. The patient subsequently became permanently blind on the side of the operation. The possibility of an unsightly postoperative scar, a keloid or a permanent fistula should be thought of.

When the patient's symptoms persist after cystectomy, partial or complete removal of the lacrimal gland is occasionally resorted to. In connection with the extirpation of the gland, the research of Michail and Vancea[17] on the chemistry and the pharmacodynamics of glands is interesting. They maintained that these glands possess an internal

14. Posey, W. C.: Excision of the Lacrimal Sac, Am. J. Ophth **3**:206-208 (March) 1920.

15. Gilbert, J. J.: Epiphora After Extirpation of Lacrimal Sac, Laryngoscope **31**:938-940 (Dec.) 1921.

16. Kayser, B.: Ein seltenes Unheil bei einer Tränensackextirpation, Klin. Monatsbl. f. Augenh. **89**:657 (Nov.) 1932.

17. Michail, D., and Vancea, P.: Existiert eine innere Sekretion der Tränendrüse? Arch. f. Ophth. **128**:38-65, 1932.

secretion whose principal properties include powerful vasoconstrictive and cardiotonic action, stimulation of the uterine muscles, of respiration and of urinary secretion and reduction of the metabolism of sugars and fats. These authors also reported that extracts of these glands accelerate cicatrization of wounds and stimulate growth.

It is entirely possible that these glands possess essential properties and thus should not be needlessly sacrificed.

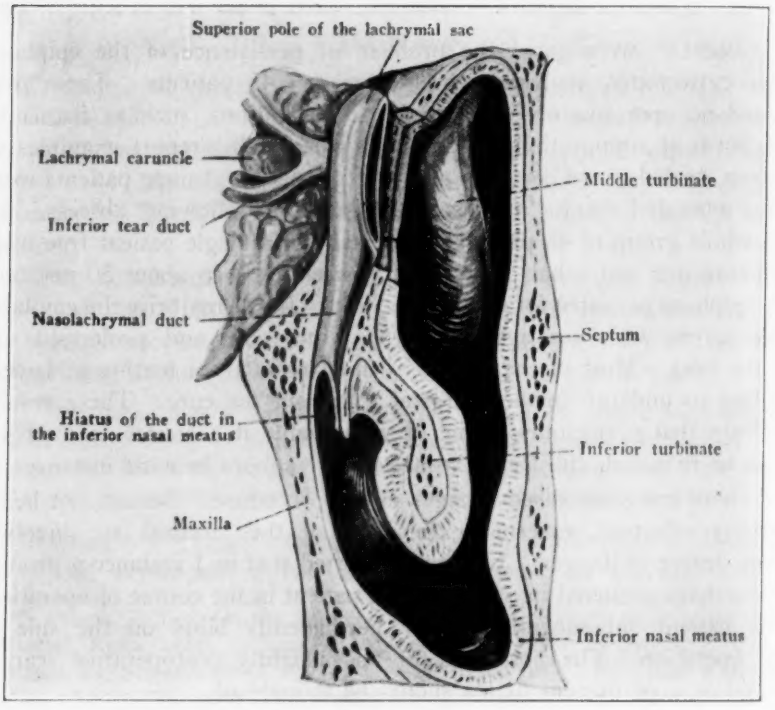

Fig. 1.—Topography of the lacrimal ducts as seen through a window in the lateral nasal wall (from Kirschner [32]).

THE RHINOLOGIST'S ROLE IN THE TREATMENT OF DACRYOCYSTITIS

The excretory portion of the lacrimal apparatus originates at the inner canthus of the eye and terminates below the forepart of the inferior meatus of the nose; its length varies from 18 to 24 mm. and its diameter from 4 to 6 mm. It is placed in a groove formed by the lacrimal bone and the nasal process of the superior maxillary bone (fig. 1). Anatomically, the major part of the mechanism is situated in the nasal chambers. When it becomes diseased, the infection ascends into the

eye and not vice versa.[18] It is not surprising, then, that there has been a long rivalry between the ophthalmologist and the rhinologist in their efforts to cure chronic dacryocystitis, each in his own way.

Knapp (cited by West),[19] as early as 1894 was so dissatisfied with the ophthalmologic treatment that he considered the lacrimal sac and accessory sinus of the nose and favored including cases of dacryostenosis within the field of rhinology.

In this division of responsibility the rhinologist has been at some disadvantage because the victim of an annoying epiphora usually seeks the aid of the ophthalmologist first. However, the patient is served best when each specialist agrees to assume an appropriate share of the treatment, that part in his own field.

While there is a divergence of opinion as to the best method of relieving the patient not only of the lacrimation but of the threat of serious involvement of the eye, it is generally agreed that in the vast majority of instances the orbital manifestation is secondary to nasal disease. Diggle[20] in a study of 120 cases of dacryocystitis found the following high percentages of incidence of abnormal conditions of the nose:

	Percentage
Injury	4.1
Abnormal breadth of nose and nasal passage:	
Narrow	10.8
Wide	13.3
Enlargement of middle turbinate bones (moderate only)	10.0
Misplacement of middle turbinate bones	3.3
Deviation of nasal septum	8.3
Enlargement of inferior turbinates	1.6
Rhinitis:	
Atrophic	5.8
Hypertrophic	5.0
Simple	1.6
Ethmoiditis:	
With closed empyema	1.6
Cystic	3.3
Nonsuppurative, with single polypi	1.6

Tremble[21] reported lacrimation eliminated by his treatment of swelling or polypoid thickening just under the anterior end of the inferior turbinate.

Stenosis of the duct is of special concern to the rhinologist because it is sometimes caused by cautery of the inferior turbinate or by some intranasal surgical procedure. I know of one such unfortunate com-

18. Post, L. T.: The Treatment of Chronic Dacryocystitis, editorial, Am. J. Ophth. **11**:63-64 (Jan.) 1928.

19. West, J. M.: Intranasal Sac Operation, Arch. Ophth. **55**:351-361 (July) 1926; Intranasal Sac Operation, Pennsylvania M. J. **44**:599-602 (Feb.) 1941.

20. Diggle, F. H.: Lacrimal Obstruction: Its Nasal Origin and Intranasal Treatment, Brit. M. J. **2**:933-935 (Nov. 19) 1927.

21. Tremble, G. E.: Epiphora of Nasal Origin: A Simple Method of Treatment, Arch. Otolaryng. **40**:494-496 (Dec.) 1944.

plication following the Caldwell-Luc operation, which was performed by a competent and reputable rhinologist. In a similar case recorded in the literature [22] the stenosis was a result of an operation for ozena.

In spite of conservative ophthalmologic and rhinologic treatment, there are still many patients who must be given the benefit of some type of major surgical operation.

CHOICE OF TYPES OF OPERATION

Since the ophthalmologist has the greatest experience in the treatment of chronic dacryocystitis, his point of view must of necessity be considered.

Parsons,[23] though admitting that in many patients intractable dacryocystitis has been cleared up by the treatment of coincident nasal inflammation, stated that in his opinion draining of the lacrimal sac by an intranasal operation (the Toti or the West operation) is difficult and inefficacious.

It is interesting to note here that May, in the fourteenth edition of his "Manual of Diseases of the Eye," as late as 1934 stated that "these intranasal operations have not come into general use since the results of extirpation of the sac are very satisfactory." However, in his last edition, in 1941, he reversed himself,[24] stating "that the results of these intranasal operations are very often favorable."

In Fuchs's [13] opinion: "The immediate results of the Toti operation in respect to tearing are good. The results of the West operation should be still better than the Toti because it preserves the musculature of the lids (Frieberg)."

The shortcomings of cystectomy have been previously pointed out. The choice now lies between a combined extranasal and intranasal operation or an intranasal one alone. Of the former, the Toti-Mosher [25] (fig. 2) and the Dupuy-Dutemps are best known.

As to the combined intranasal and extranasal operation, Mosher reported the results in 75 cases in which his modification of the Toti method was used. Of 42 patients who replied to his follow-up letters, 90 per cent were cured of the purulent discharge and 75 per cent were

22. Maliniak, J.: Dacryostenosis Following Ozena Operations and Its Cure, Laryngoscope **35**:303-308 (April) 1925.

23. Parsons, J. H.: Diseases of the Eye, ed. 8, New York, The Macmillan Company, 1936, p. 635.

24. May, C. H.: Manual of Diseases of the Eye, ed. 17, Baltimore, William Wood & Company, 1941, p. 84.

25. Mosher, H. P.: Combined Intranasal and Extranasal Operation of the Lacrimal Sac (Mosher-Toti), Ann. Otol., Rhin. & Laryng. **32**:1-14 (March) 1923.

cured of the epiphora. Clark [26] claimed cures in nearly 100 per cent. Dupuy-Dutemps [27] reported 1,000 cases in which his method had been used, with complete cures in 94.8 per cent. Averbakh and Ivanova [28] employed the Dupuy-Dutemps technic. They performed this on 1,692 patients, of whom only 1,200 were observed for some time after the operation. They reported good results in 95.83 per cent.

Though the combined operation seems to have the advantage of solving the problem of postoperative tearing, it still falls short of the ideal since the same or better results can be accomplished by the nasal

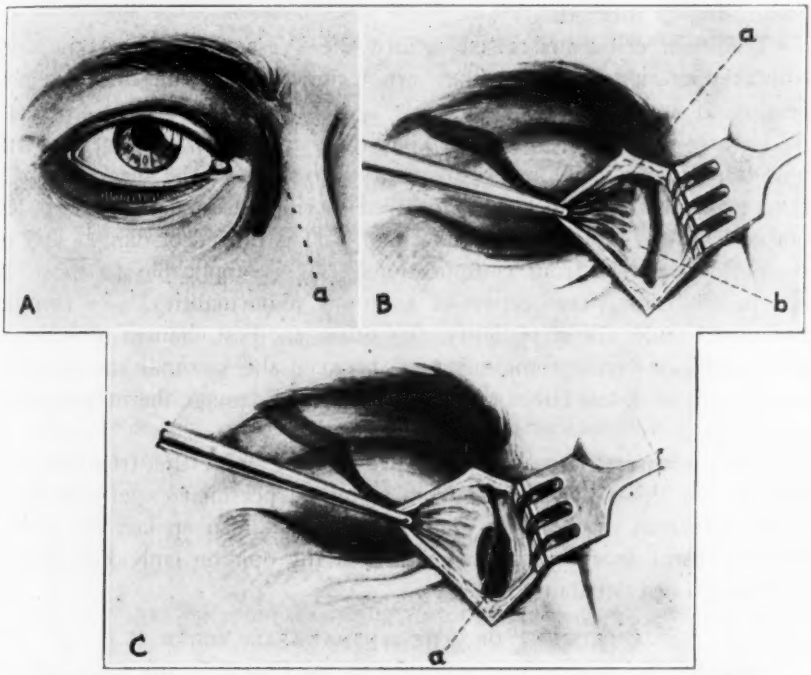

Fig. 2.—Toti's operation (from Kirschner [32]): *A*, the incision (indicated by *a* . . .). *B*, supramaxillary process exposed with the lacrimal bone: *a* indicates the orbicularis muscle with the median palpebral ligament; *b*, the lacrimal sac. *C*, operation completed: *a* indicates the anterior end of the middle turbinate.

route alone. The intranasal route has the added advantage of avoiding an external scar and also preserves the middle turbinate, which is sacrificed in some of the combined methods. There is abundant evi-

26. Clark, J. S.: A Combined Intranasal and Extranasal Operation for Dacryocystitis, Illinois M. J. **42**:104-110 (Aug.) 1922.

27. Dupuy-Dutemps, L.: Observations sur millie dacryostomies plastique, Ann. d'ocul. **170**:361-414 (May) 1933.

28. Averbakh, M., and Ivanova: Douze cents operations de dacryocystorhinostomie plastique, Ann. d'ocul. **172**:913-936 (Nov.) 1935.

dence in the literature to support this view. The claims made for permanent cures by intranasal methods are as follows: Polyak, 80 per cent; Faser, 78 per cent; West, 90 per cent; Kofler, 100 per cent; Whale Lawson, 63 per cent; Bockstein, 80 per cent (quoted by Matis [29]).

In 1926 West [19] reported having operated by his technic on 1,600 of 2,500 patients encountered and obtained cures in 90 per cent. In 1941 he reported similar results in an additional 400 patients.

Wiener and Sauer [30] described an operation of their own, and their results "justified their expectations." Sauer [31] reported that by this operation he obtained fully as good results as West did by the Wiener-Sauer simpler method.

The chief criticisms raised against the West, the West-Halle and similar operations are that they are technically difficult and are not performed under direct vision.

In any attempt to establish conditions in which the lacrimal sac will drain satisfactorily and permanently into the nose the surgeon's goal is to use a method which (1) does not sacrifice normal tissues, (2) is not complicated and is readily executed, (3) is devoid of danger and is comparatively free from complications, (4) is applicable to most, if not to all, cases, irrespective of anatomic abnormalities, (5) can be performed under direct visibility, (6) offers the best chances of success, (7) establishes wide communication between the lacrimal sac and the nasal cavity and, last but not least, (8) does not damage the musculature of the lids.

After scanning the vast literature dealing with the treatment of patients for this affliction and from a limited personal experience may I call attention to the Veis-Claus [32] operation, also spoken of as the transapertural dacryocystotomy, which in my opinion embodies all the aforementioned attributes?

EVOLUTION OF THE INTRANASAL ROUTE

Attempts to relieve dacryocystitis by operating on the lacrimal sac were made as far back as 50 A. D. by Galen and 100 A. D. by Celsus. The intranasal operation was developed notably by Caldwell in 1893, Hopman (cited by Ritter) in 1885, Killian in 1889, Passow in 1901, Stazza in 1908, Okuneff (cited by West) in 1909, Polyak, Bryan and Yankauer in 1912, Choronshitzky (cited by Halle) in 1914, Hangar

29. Matis, E. T.: The Intranasal Approach to the Lacrimal Sac, Laryngoscope **80**:357-365 (May) 1943.

30. Wiener, M., and Sauer, W. E.: New Operation for Relief of Dacryocystitis Through Nasal Route, J. A. M. A. **75**:868-873 (Sept. 25) 1920.

31. Sauer, W. E.: Intranasal Dacryocystotomy, Arch. Otolaryng. **30**:973-985 (Dec.) 1939; Dacryocystotomy: Combined Methods, Ann. Otol., Rhin. & Laryng. **32**:25-28 (March) 1923.

(Footnotes continued on next page)

in 1915, Wiener and Sauer in 1920 and, last but not least, Veis [33] in 1921 and Claus [34] in 1928.

TECHNIC OF THE VEIS-CLAUS PROCEDURE

Though general anesthesia may be employed, local and infiltration anesthesia with preoperative sedation is preferable.

On each side of the piriform ridge a procaine-hydrochloride epinephrine hydrochloride solution is injected. Intranasally the infiltration of the mucous membrane should reach as far up as the middle turbinate. The skin should be infiltrated up to the orbital ridge.

The incision for the purpose of forming the intranasal flap is similar to that of West (fig. 3*A*); accordingly, the flap is folded downward. External to the piriform ridge, soft tissues are now loosened from its margin along the frontal process of the superior maxilla up to the lacrimal sac. A Joseph periosteal elevator is a useful instrument for this purpose. A Killian speculum is now inserted (fig. 3*B*) so that its two blades expose fully the frontal process of the superior maxilla. With a flat chisel, two incisions of bone are now made, the upper one being made first in the direction of the internal canthus. The lower incision is made approximately parallel at a distance of 1 to 1.5 cm. from the first. The intervening mobilized fragment of bone is caught in the septum forceps and removed (fig. 3*C*).

Rhinologists who have had experience in performing osteotomies in rhinoplasties will find this procedure more readily executed. Substituting a Joseph angular saw for the chisel and the mallet is advantageous.

A probe introduced through the lacriminal duct at this stage by an ophthalmologist and held in position will greatly facilitate identification of the sac.

After incising the sac or excising a portion thereof the mucous membrane flap, previously formed, is replaced in such a manner that it will not obstruct the newly formed short-circuited passageway for the tears and tamponed into its original position. A hole is punched in the flap for the purpose of keeping the tear passage open. In a very narrow nose a submucous resection may have to precede this operation.

Matis [29] has operated according to this method on 50 patients in the past ten years (he refers to it as "transparent dacryorhinocystotomy") and has obtained good results in 75 to 85 per cent.

POSTOPERATIVE COURSE

In spite of considerable ecchymosis and swelling of the lower lid following the Veis-Claus operation, there is a noticeable improvement within twenty-four hours as far as overflowing of tears is concerned.

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32. Kirschner, M.: Operative Surgery: The Ear, Air Passages and Neck, Philadelphia, J. B. Lippincott Company, 1937, pp. 98-100.

33. Veis, J.: Eine neue Methode zur Operations des Tränensackes von der Nase aus, Arch. f. Laryng. u. Rhin. **34**:84-86, 1921.

34. Claus, H.: Wie wird die endonasale Tränensackdrainage (Dakryocystorhinostomie) ein technisch leichter Eingriff? Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres **26**:121-124 (Nov.) 1927.

Though the immediate improvement is striking, subsequent progress is somewhat slow. Some surgeons may claim earlier results than others, and this may be ascribed to more thorough surgical procedure or better selection of cases. The patient may leave the hospital twenty-four to forty-eight hours after the operation.

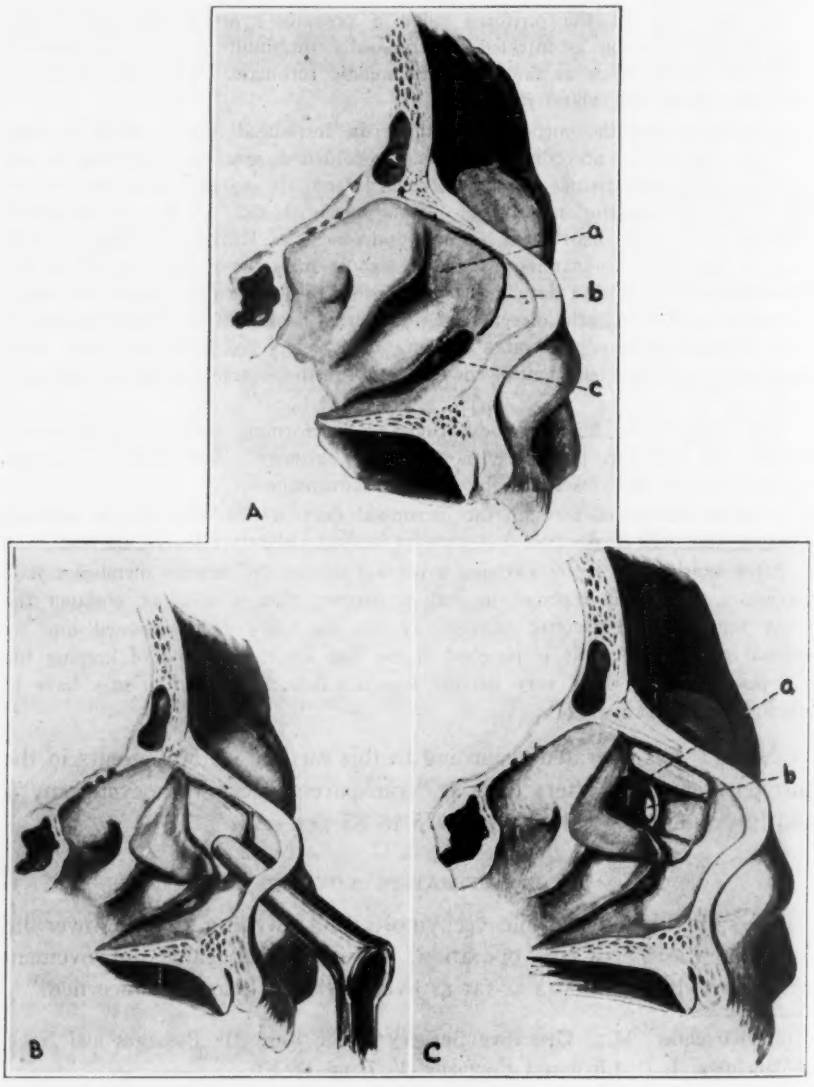

Fig. 3.—Veis-Claus operation (from Kirschner [32]). *A*, line of incision in the intranasal operation: *a* indicates the area of the lacrimal sac projected; *b*, the line of incision; *c*, the hiatus of the lacrimal duct.

B, folding downward of the flap; insertion of a Killian speculum. *C*, lacrimal sac opened after resection of the frontal process: *a* indicates the window in the mucosal flap; *b*, the opened lacrimal sac.

Some excessive tearing should be expected because of crust formation in the nose, which causes reflex irritation and more than normal lacrimation. Crusts may also obstruct the newly formed canal. In due time, after new epithelization takes place, the patient becomes free from symptoms.

POSTOPERATIVE CARE

The nose should be kept free from crusts. The patient may be taught to remove them at home by means of nasal douches. In order to prevent formation of synechiae, the new channel should be irrigated via the inner canthus with some preparation of silver protein or a weak solution of epinephrine hydrochloride combined with an antiseptic. Tincture of belladonna U. S. P. administered in physiologic doses helps to tide over a difficult postoperative period. The preexisting conjunctivitis must receive appropriate attention.

SUMMARY

For decades both the ophthalmologist and the rhinologist have been making serious attempts to solve satisfactorily the problem of chronic dacryocystitis both because of its plaguing epiphora and because of the possible dangers to the eye.

Any treatment for lacrimal stenosis, to be 100 per cent efficient, must relieve the patient's chief complaint, namely, overflow of tears and collection of pus in the eye. Numerous conservative measures, if the literature is any criterion, apparently have not met with much favor in curing chronic dacryocystitis. Removal of the sac, even with subsequent excision of the lacrimal gland, has not been gratifying to many ophthalmologists.

Combined intranasal and extranasal operations are favored by many ophthalmologists. These have some of the objectionable features of cystectomy, such as external incision and possible keloid and fistula formation.

The rhinologists, on the other hand, have devised several operations which aim essentially to drain the tears as well as the infection of the sac into the nose. Recorded in the literature are thousands of cases in which such operations have been successful, which should convince even the most skeptical that chronic dacryocystitis can be alleviated by means of intranasal operation.

The Veis-Claus operation via the apertura piriformis is the latest method of approaching the sac. It overcomes all the criticisms of other intranasal operations because of its comparative simplicity of technic and because it is performed under direct visibility.

CONCLUSIONS

1. As is generally conceded, orbital manifestations in cases of chronic dacryocystitis are only secondary to the ascending infection.

2. In many cases the epiphora may be relieved by treating the inflammatory process in the nose alone.

3. Since by far the major part of the excretory mechanism is located in the nasal chamber, when it is diseased it belongs also in the domain of the rhinologist.

4. The Veis-Claus approach is the simplist procedure and is at least as efficacious as other intranasal and extranasal operations.

5. Cooperation between the ophthalmologist and the rhinologist offers the patient the best chance for complete and early recovery.

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AEROHEMATOMA OF THE SINUSES

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A HEMATOMA by definition is a tumor containing effused blood. That such a tumor may occur within a paranasal sinus has been reported by several observers.[1] Hematoma of the paranasal sinuses is a relatively new and interesting diagnostic entity which has come to light in the present day accelerated flying program. It is a complication encountered occasionally in obstructive aerosinusitis.[1b] Because it is directly related to the latter condition we suggest that the term "aerohematoma" be applied to it.

FREQUENCY

We have recorded and studied 12 cases of aerohematoma during the past two years. In 11 of these cases the hematoma occurred during a simulated flight in the low pressure chamber. These were the only cases recorded by us in over one hundred thousand such flights; aerohematoma is, therefore, not a frequent finding. It is reasonable to believe that in many cases of aerosinusitis the patient does not seek medical attention. In at least some few of these undiagnosed cases it is likely that aerohematoma develops with symptoms of insufficient severity to cause the patient to seek medical treatment.

From all the flying fields for which this hospital is the diagnostic center only 1 patient with aerohematoma has been referred. This man acquired aerohematoma during actual flight over a short period. He had no difficulty before or after this episode.

In the German literature, Hermann [1a] reported 4 cases of spontaneous hematoma of the paranasal sinuses in which the patients were aviators. It was not stated over how long a period these patients had the condition or how many flights were involved.

1. (*a*) Hermann, A.: Laceration of the Mucous Membrane and Hematoma of the Nasal Sinuses in Aviators, Ztschr. f. Hals-, Nasen- u. Ohrenh. **47**:103 (Dec.) 1940; abstracted, Arch. Otolaryng. **37**:739 (May) 1943. (*b*) Campbell, P. A.: Aerosinusitis: Its Cause, Course and Treatment, Ann. Otol., Rhin. & Laryng. **53**:291 (June) 1944. (*c*) Wright, R. W., and Boyd, H. M. E.: Aerosinusitis, Arch. Otolaryng. **41**:193 (March) 1945.

LOCATION OF AEROHEMATOMA

As shown in table 1, in our series the most frequent site was in the frontal sinus.

TABLE 1.—*Location of Aerohematoma*

Location	Cases
Antrum alone	3
Frontal sinus alone	7
Antrum and frontal sinus	2 (possibly 3)

Hermann [1a] in his series of 4 cases found the hematoma in the frontal sinus in 3 and in the maxillary sinus in 1. Campbell [1b] also found the frontal sinus the site of predilection.

SYMPTOMATOLOGY

The outstanding symptom in our cases was pain coming on during actual or simulated flight. Other symptoms noted were soreness over the sinus areas, numbness of the face and the teeth, discharge of fresh or old blood from the nose and, in a single case, dizziness.

Pain was common to all cases. When the frontal sinus was involved, pain was severe and usually lasted for a short period after descent. Only 1 man complained of pain on ascent (case C). Pain and headache or soreness over the sinuses, less severe than the original pain, often persisted from one to several days. In some cases it was severe enough to necessitate hospitalization. When the hematoma was found in the maxillary sinus, the predominant symptoms were facial pain, toothache and numbness of the face and the upper teeth. (See case 1 in report of cases and table 2, cases A and H.) When the maxillary sinus was involved the pain as a rule persisted for several days. When the frontal sinus was involved the pain was relieved for the most part by nasal shrinkage, but when the maxillary sinus was involved antral lavage was also helpful.

One patient (table 2, case I) had dizziness as the chief complaint. This symptom came on shortly after a simulated flight, and because of it the patient was admitted to the hospital. Another patient had the initial symptom of severe toothache (table 2, case A) (case 1 in report of cases). This man was checked by the dentist before he presented himself to the nose and throat clinic. One patient, a flyer, had pain only momentarily during descent. At the time the pain, although transient, was sharp and severe. This man sought treatment because the same symptoms recurred several times on successive flights. His case, with roentgenograms, has been previously reported by us.[1c]

Of our 12 patients, none had bloody discharge from the nose or the throat as the initial symptom. It might be expected that early spon-

taneous discharge of blood would be common, but this was not found to be so. Several patients were observed without bloody discharge being noted at any time during the entire course of the hematoma. Most of these patients had hematoma of the frontal sinus. Occasionally a small amount of blood was seen postnasally many days after the flight. In some of the cases in which the hematoma occurred in the antrum, clots of blood were washed out on lavage. In 2 cases (table 2, cases C and H) blood was seen in the mucous membrane at the time of operation for the relief of symptoms.

MacKenzie [2] reported discharge of old blood occurring eight days after the onset in a case of frontal aerosinusitis. This case might well

TABLE 2.—*Site and Symptoms*

Case	Site of Hematoma	Symptoms
A	Right antrum	Sharp pain in right side of face and teeth; pain in teeth persisted one day
B	Right frontal sinus	Intense pain in right frontal sinus region; pain persisted about one week then subsided somewhat; three attacks of aerosinusitis
C	Right antrum and left frontal sinus	Severe pain in right frontal sinus region, persisting many days
D	Right frontal sinus	Pain in right frontal sinus region, dull pain, persisting for one day
E	Left frontal sinus and left antrum	Sharp pain over left eye; headache persisted two weeks
F	Right frontal sinus	Severe pain over right eye; some headache for several days
G	Left and later right frontal sinus	Severe pain in left frontal sinus region; some pain for several hours
H	Left antrum	Severe pain in left side of face; teeth and face numb; many days' duration
I	Left frontal sinus	Sticking sensation in middle of forehead; dizziness two days after this, of several days' duration
J	Right frontal sinus and right antrum	Pain in region of right frontal sinus, persisting several days
K	Left antrum	Upper left teeth numb; condition same on several days after flight
L	Both frontal sinuses	Sharp pain in left frontal sinus region—several occurrences, all of short duration

have been one of aerohematoma. The roentgenogram presented a cloudy left frontal sinus, which cleared in one month; the discrete rounded shadow was not present.

Hermann [1a] described the symptoms in his 4 cases as sudden severe pain occurring during flight associated with a sensation of tearing of tissue in the involved area.

Correlation of Symptoms Related to the Site of the Lesion.—Generally speaking there was a rather definite relationship between the site of the hematoma and the symptoms experienced by the patient. This might seem to be an obvious finding. However, a correlation of

2. MacKenzie, J. G.: Barotrauma, Canad. M. A. J. **49**:301 (Oct.) 1943.

this sort was not always noted by us in cases of aerosinusitis without hematoma formation. When the hematoma was in the antrum, there was either pain or numbness or both over the affected area. (See table 2.) On the other hand, in many cases of aerosinusitis observed by us the pain was felt over the frontal sinus although the pathologic site was found in the antrum on the same side. Therefore, there was greater correlation between the site of the lesion and the symptoms in aerohematoma than in uncomplicated aerosinusitis.

TABLE 3.—*Bleeding in Aerohematoma*

Case	Blood at Time of Flight	Blood Following Flight
A	None	Old blood washed from antrum
B	None	Some nasal bleeding after several days
C	None	Blood on antral washing
D	None	Old blood postnasally two weeks later
E	None	Old blood from left side of nose three days later
F	None	Some dark blood on third day
G	None	None
H	None	Old blood many days later and on operation also
I	None	None
J	None	Old blood discharged from nose several days later
K	None	Old blood on antral washing
L	None	None

TABLE 4.—*Predisposing Conditions*

Case	Predisposing Conditions
A	Slight cold at the time of flight; right side of nose congested
B	Moderate congestion of the nasal mucosa with no pus and some bleeding
C	Some redness and congestion of the right side of the nose; no cold; no pus
D	Cold at time of flight; very little seen at examination; space in the right middle meatus (side of the pathologic development) good; past history noncontributory; little seen to account for aerosinusitis
E	Cold at the time of flight. Two weeks later: little seen; space good; no anatomic reason for aerosinusitis; septum, etc., good
F	Had had a cold for some months; slight septal deviation to opposite side; some congestion of side affected
G	Stuffiness on left side of nose from a cold; marked congestion on this side observed a few days after flight
H	Cold at time of flight; examination shows congestion; septum good; space adequate
I	Nose normal on examination; space good; definite sinusitis found, however, by washing the antrum
J	Cold for two days; marked congestion in right side of nose; mucopus in middle meatus; left side of nose normal
K	Congestion and slight discharge in left middle meatus, the side of the trouble
L	Possibly slight cold at time of flight; certainly very little to account for pathologic development

ETIOLOGIC FACTORS

Predisposing Factors.—In 8 of the 12 cases there was a history of a slight cold or of sinusitis at the time of the flight. After examining the nose and the throat in each case we had the impression that often relatively little that was pathologic could be found to account for the sudden blockage of the ostium of the sinus. Congestion and a small amount of mucopus were found on the affected side in a few cases. In the majority there was slight or no congestion. The nasal septum did not appear to

play a role, as the air space in all cases was good. The septum was deviated to the opposite side in only a few cases. This lack of preexisting pathologic change is rather at variance with the findings in the ordinary case of aerosinusitis, for in this condition there is nearly always a predisposing factor.[1c]

Mechanism of Production.—More or less rapid changes in atmospheric pressure are necessary for the production of hematoma. In all except 1 case the symptoms developed on descent. Furthermore, the rapidity of descent seems to be the important factor rather than the altitude. In several cases symptoms developed on descent from only 5,000 feet (1,500 meters) (see table 4). Lighter air becomes trapped in a susceptible sinus as the denser air from the outside presses on the sinal ostiums. The relative negative pressure thus developed pulls the mucosal layers apart and ruptures small vessels, with the formation of a hematoma. This is the train of events as we would reconstruct it from the pathologic observations and the symptoms.

TABLE 5.—*Altitude at Which Symptoms Occurred*

Case	Altitude
A	Descent from 30,000 feet; symptoms at 17,000 feet (about 9,000 to 5,000 meters)
B	Descent from 5,000 feet; symptoms at 2,000 feet (about 1,500 to 600 meters)
C	Ascent; symptoms at 15,000 feet (about 4,500 meters)
D	Descent from 38,000 feet; symptoms at 30,000 feet (about 11,500 to 9,000 meters)
E	Descent from 30,000 feet; symptoms at 25,000 feet (about 9,000 to 7,500 meters)
F	Descent from 5,000 feet
G	Descent from 30,000 feet; symptoms at no stated altitude
H	Descent from 38,000 feet; symptoms at 10,000 feet (about 11,500 to 3,000 meters)
I	Descent from 30,000 feet; symptoms at no stated interval
J	Descent from 38,000 feet; symptoms at just below 30,000 feet
K	Descent from 38,000 feet; no altitude mentioned as painful
L	Descent from about 1,000 feet (about 3,350 meters) in actual flight; pain present most of the way down

The amount of negative pressure necessary to produce this train of events may be very slight. In several instances roentgenograms taken directly after the flight showed nothing, while those taken a few days later showed a hematoma, there being no intervening trauma and little discomfort of any kind noted by the patient. One patient (case 3 in the report of cases) had three recurrences of aerosinusitis on descents from 5,000 feet. The first attack produced a typical aerohematoma of the right frontal sinus. The other two attacks of pain occurring in the same region during the clearing of the hematoma produced no new pathologic condition. The roentgenograms continued to clear during these additional attacks of aerosinusitis.

It is of interest that hemorrhage of the sinuses has been reported as due to negative pressure produced in suction displacement treatments.[3]

3. Furrer, E. D.; Stanard, D. C., and Kuykendall, J.: Hemorrhage into the Paranasal Sinuses Following Suction Displacement Irrigation, Arch. Otolaryng. **33**:305 (Feb.) 1941.

TABLE 6.—*Clearing as Seen by Roentgen Recheck*

Case	Date of Flight	Roentgen Report
A	June 21, 1944	June 22: large round shadow almost filling the right antrum; other sinuses clear June 29: almost general opacity of right antrum July 3: general opacity of right antrum August 7: only light haze in right antrum, which shows almost complete clearing Clearing time: approximately 45 days
B	May 4, 1944	May 4: large round shadow in outer part of fairly large right frontal sinus May 11: little change in right frontal sinus May 18: little change in right frontal sinus May 25: no change in right frontal sinus June 5: some decrease of density and of size June 21: considerable decrease of density and of size but a shadow still cast; hematoma not completely resorbed Clearing time: 52 days plus
C	June 23, 1943	July 3: large round shadow in lateral part of right antrum, almost filling it; remainder of sinuses hazy July 26: several rounded shadows seen in lateral part of right antrum; medial part of antrum clearing; now a round shadow in medial lower part of left frontal sinus where none existed previously August 9: considerable clearing but still some haziness of right antrum; shadow in left frontal sinus now not present August 23: one small upper and one small lower shadow only now October 1: complete clearing (following operation on Sept. 1) Clearing time: antrum, 60 days plus; frontal sinus, 13 to 30 days
D	Aug. 1, 1944	August 2: large round shadow in outer upper part of right frontal sinus; frontal sinus of medium size August 17: generalized haziness of right frontal sinus almost obscures round shadow August 28: shadow a little more discrete again; less general haze Clearing time: 26+ to 33 days
E	June 1, 1944	June 15: large round shadow in medial portion of large left frontal sinus; smaller shadow in lateral part of left frontal sinus June 26: medial round shadow smaller, less dense; lateral shadow more discrete July 3: shadows less distinct July 4: considerable clearing July 24: little change August 1: complete clearing Clearing time: 50 to 60 days
F	April 15, 1944	April 15: large frontal sinus May 2: two discrete round shadows in central part of right frontal sinus; round shadow in left antrum, lower part May 17: general haziness of right frontal sinus; shadow in left antrum less distinct May 26: little change June 5: almost complete clearing of frontal and maxillary sinuses Clearing time: approximately 45 days
G	July 20, 1944	July 24: round shadow in outer part of moderate-sized left frontal sinus August 15: round shadow in left frontal sinus unchanged; now a large round shadow almost filling small right frontal sinus Record of case unfinished
I	June 1, 1944	June 15: round shadow in lateral part of left frontal sinus June 22: much less distinct June 30: almost entirely cleared Clearing time: about 24 days plus
J	Oct. 1, 1943	October 10: right frontal sinus uniformly clouded; slight haziness of right antrum October 28: much less haziness of left frontal sinus November 12: complete clearing of right frontal sinus; now a small round shadow in upper part of right antrum which did not appear distinctly on other roentgen examinations Clearing time: approximately 42 days for right frontal sinus

TABLE 6.—*Clearing as Seen by Roentgen Recheck—Continued*

Case	Date of Flight	Roentgen Report
K	July 24, 1943	August 4: left antrum entirely opaque (this directly after washing out old blood) August 25: slight haziness of left antrum only Clearing time: about one month
L	Nov. 26, 1943	November 28: large round shadow on septal wall of left frontal sinus December 17: now round shadow on both sides of frontal septum January 5: unchanged February 3: shadow in left frontal sinus resorbed; that in right smaller February 14: unchanged February 26: almost completely cleared Clearing time: left frontal sinus, about 60 days; right frontal sinus, about 70 days
H	.....	Patient operated on

TABLE 7.—*Clearing Time*

A	45 (antrum)	I	24+ (frontal sinus)
B	52 (frontal sinus)	J	Approximately 42 (frontal sinus)
C	60 (antrum); 13 to 30 (frontal sinus)	K	30 (antrum)
D	26 to 33 (frontal sinus)	L	60 (left frontal sinus)
E	50 to 60 (frontal sinus)		70 (right frontal sinus)
F	45 (frontal sinus)	H	Patient operated on
G	Incomplete (frontal sinus)		

The mechanism here is likely identical with that encountered in cases of aerohematoma as described in a foregoing paragraph.

The mechanism producing aerohematoma is very similar to that producing hemorrhage in the drum membrane in aero-otitis media.

Roentgen Appearance of the Hematoma.—The roentgen appearance is best illustrated by the reproductions shown with the case histories. The shadow of hematoma is rather striking as a rule. Usually a well defined round shadow is present. Later the entire sinus may become cloudy, probably from accompanying reaction to the blood, and then the discrete shadow is no longer visible. Thereafter the appearance is indistinguishable from sinusitis of any sort. The round shadow often does not appear again, as resorption occurs, and the entire cloudiness clears up at the same time. In cases of antral cyst, which may resemble hematoma on the roentgenogram, a discrete round shadow is often obscured by reaction which on clearing reveals the shadow again. In 1 case (case 2) a cyst disappeared according to the roentgenogram as well as the hematoma in another sinus. This was after puncture with liberation of the cystic fluid.

COMMENT

As shown in table 7, the time necessary for resorption of the hematoma in our 11 cases was about three to ten weeks. The exact number of days in any case is only an approximation, as the roentgenograms were not spaced close enough or taken soon enough after the flight to

enable us to determine it exactly. Nevertheless, there is a rough similarity of clearing time in all the cases.

Differential Diagnosis.—The differential diagnosis presents no difficulty after the condition has been seen a few times and its possibilities considered. A history of flight with pain on descent or even on ascent usually gives a clue to what may be found on the roentgenogram. The discharge of some old blood is suggestive. This may not occur and often occurs too late to be of diagnostic value. (See table 3.) Many of the patients, however, are seen late, after the headache has persisted for some time. Following or during a flight, the development of pain in the face, toothache and numbness are almost certain to indicate presence of a hematoma. We have never seen simple aerosinusitis of the maxillary sinus persisting for any appreciable time or presenting the aformentioned symptoms which was not associated with hematoma.

The roentgen appearance has already been discussed, as well as the course of the lesion. The course is of diagnostic significance. Hematoma absorbs in several weeks (see table 7), which is an observation not commonly made with regard to any other lesion.

Washing old blood from the antrum confirms the diagnosis of hematoma. Blood may not be free in the cavity and may not be encountered by the needle, so that the absence of blood on washing does not rule out hematoma.

Mucocele of the frontal sinus may present a similar roentgen appearance. It is rare, however, is not absorbed and has not the history of acute onset with flight. Cyst of the maxillary sinus may resemble the hematoma roentgenographically. Here also the pain is not of acute onset with flight, and cystic fluid is found, while old blood may be found in hematoma. (See case 2.)

Pathology.—The pathologic aspects of aerohematoma have already been discussed by us in an earlier paper.[1c] One case was presented in some detail, in which operative intervention was necessary because of pain. At operation a section of the membrane was obtained. This showed that the hematoma was subepithelial, occurring in the loose connective tissue, and was not between the membrane and the bony wall of the sinus. A reproduction of the slide used to illustrate the article just mentioned is included in this report (fig. 1). In 2 experiments made on dogs by P. Campbell at Randolph Field, Texas, the pathologic observations were essentially the same.[4] The sections were almost identical with the one in our case. Pathologic material is not abundant, as operation is rarely called for.

Treatment.—For the most part, little treatment other than nasal shrinkage is required for aerohematoma. Time is the important element;

4. Campbell, P. A.: Personal communication to the authors.

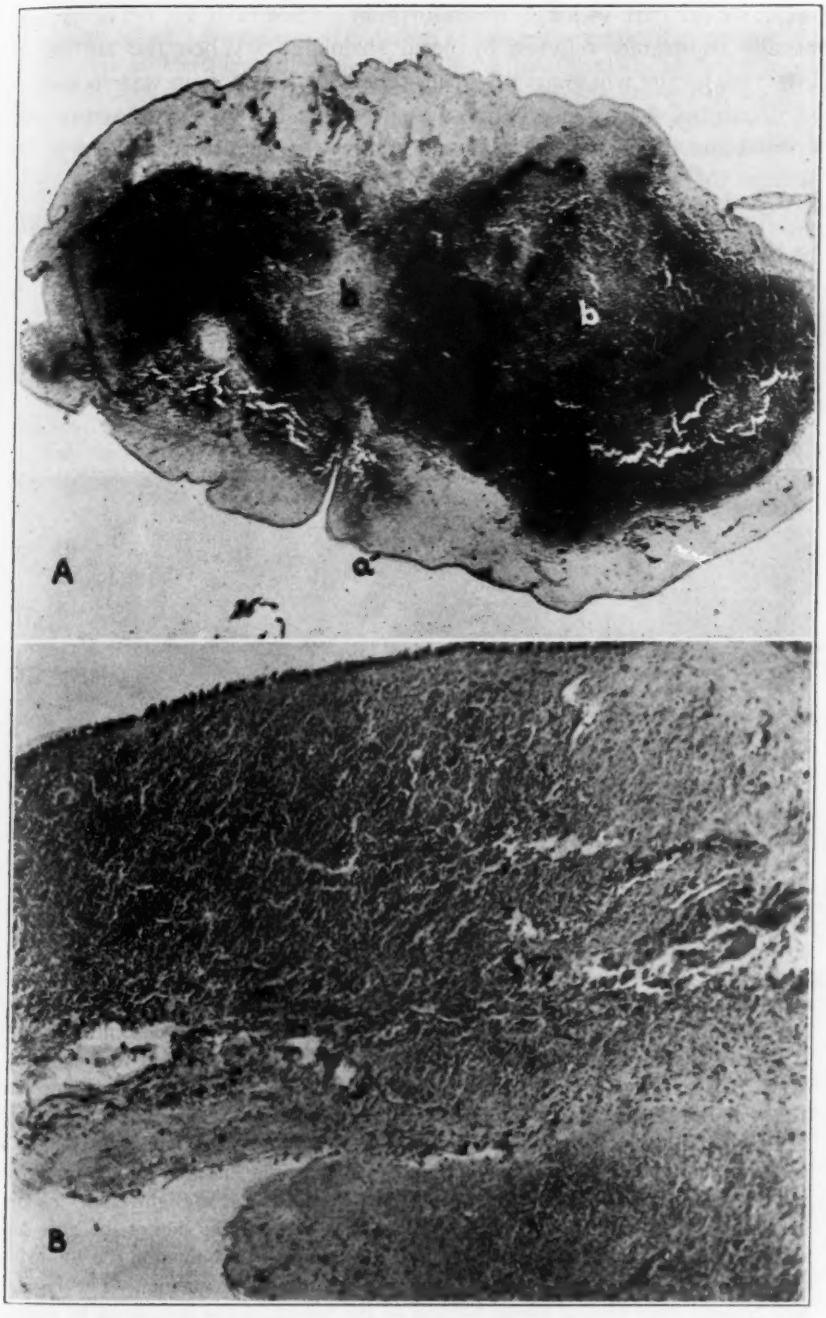

Fig. 1.—*A*, hematoma in the subepithelial tissue. The hematoma forms a polyplike mass covered by epithelium (*a*) with a collection of blood (*b*) below the epithelium in the stroma of the sinal mucosa. *B*, higher power magnification showing the extravasation below the epithelium in the stroma.

several weeks are required for resorption. (See table 7.) The pain is usually completely relieved by nasal shrinkage. When the antrum is involved, lavage will generally bring relief. In 1 case, pain was so severe, so uncontrolled by conservative measures that the involved antrum was opened and the hematoma removed; there was uneventful recovery. It is from this case that sections of the membrane are shown.

It should be emphasized that surgical intervention is not necessary in the majority of cases. The condition should be correctly diagnosed and treated conservatively.

REPORT OF CASES

The progress of the hematoma is shown in the cases presented, in which roentgenograms were taken at frequent intervals.

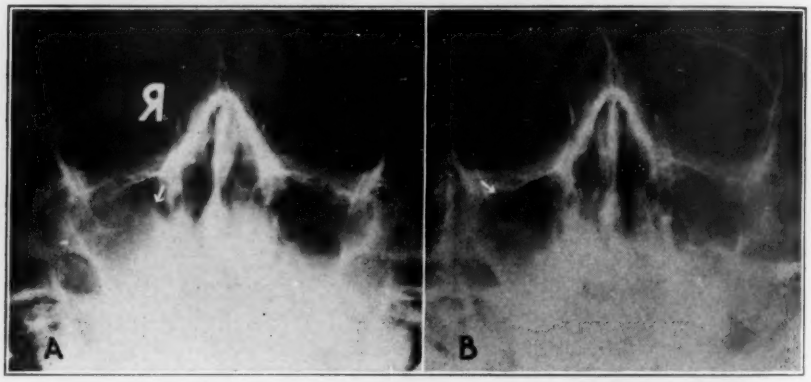

Fig. 2 (case 1).—*A*, roentgenogram showing a hematoma in the right antrum. A rounded upper border is seen. *B*, roentgenogram made forty-five days later, showing a considerable clearing of the right antrum.

CASE 1.—On June 21, 1944 a patient came to the hospital because of pain in the upper teeth on the right side. That afternoon he was on a routine flight to 30,000 feet (about 9,000 meters) in the low pressure chamber. On descent at about 17,000 feet (about 5,000 meters) he felt an extremely sharp pain in the right side of the face and teeth. There was no pain in the frontal sinus area. An immediate ascent of 1,000 feet (about 300 meters) brought little or no relief. On the termination of the flight he went to the dental clinic because of the pain in his teeth, but no dental abnormality was found. He then came to the hospital. There was no discharge from the nose. At the time of the flight he had a slight cold. Examination shortly after the flight showed congestion of the right side of the nose and slight swelling over the right side of the face. Roentgen examination the following day showed a large round shadow almost filling the right antrum. The antrum was lavaged after several weeks because of the failure of the hematoma to resorb, and old blood was washed out. By August 7, some forty-five days after the flight, there was only slight thickening of the right antral membrane with almost complete clearing. (See fig. 2.)

CASE 2.—A student of aviation made a flight in the low pressure chamber to only 5,000 feet (about 1,500 meters). On descent he had a severe pain over the right eye. There was no bleeding at the time of the flight, but there was some the second day, with dark clots. He came to the nose and throat clinic the day of the flight and was much relieved by nasal shrinking. Roentgenograms taken on this day showed only slight haziness on the floor of each frontal sinus. At the time of the flight he had a "cold," which had persisted for several months. There was frontal pain for several days after the flight, but it was not marked. Seventeen days later, when the second roentgenogram was taken, there were two round shadows in the central part of the right frontal sinus. A round shadow was also seen in the left antrum, which on puncture was found to represent a cyst and not a hematoma. Fifty days after the flight complete clearing was shown by the roentgenogram. The exact time of the appearance of the hematomas in the frontal sinus, however, is not known, as the roentgen studies were made some time apart. (See fig. 3.)

CASE 3.—A student of aviation, on May 4, 1944, made a routine check flight in the low pressure chamber to 5,000 feet. On descent, at 2,000 feet (about 600 meters) he suffered an intense pain in the right frontal sinus area. He was sent

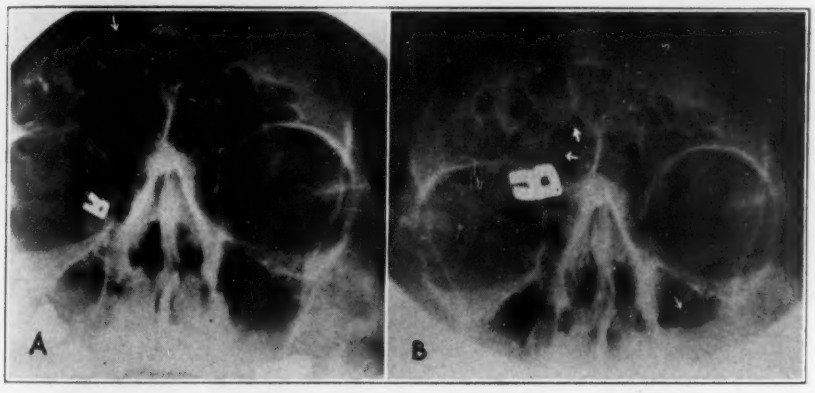

Fig. 3 (case 2).—*A,* roentgenogram made directly after the flight, showing only cloudy antrums with no pathologic alteration of the frontal sinuses. *B,* roentgenogram made several days later, showing rounded shadows in the right frontal sinus. The right antrum was found to contain a nonsecreting cyst.

immediately to the nose and throat clinic where some relief was obtained after nasal shrinkage. A roentgenogram taken on this date showed a large round shadow in the outer inferior part of a rather large right frontal sinus. There was some nasal bleeding from this side after the flight. The headache persisted for about ten days. On May 20 and June 9 he made other check flights in the low pressure chamber to 5,000 feet, with recurrence of pain in the right frontal region on descent but no increase of the aerohematoma and no appearance of a new one. By June 21, about fifty-two days after the flight, almost complete clearing was shown by the roentgenogram. He still complained of headache of a minor nature.

The outstanding feature in this case was recurrence of pain in the same region on several flights. No new lesions resulted from these attacks. (See fig. 4).

CASE 4.—A patient came to the nose and throat clinic complaining that he had suffered from an intermittent headache over the left eye since a flight in the low

pressure chamber two weeks previously. There was no difficulty on ascent to 30,000 feet (about 9,000 meters). On descent, at about 25,000 feet (about 7,500 meters) there was a severe pain over the left eye. A dull headache in this region persisted. Three days after the flight he blew some old, dark blood out of the left side of the nose. Examination gave essentially negative results except for roentgen findings. The roentgenogram of the sinuses taken on the day of entry, two weeks

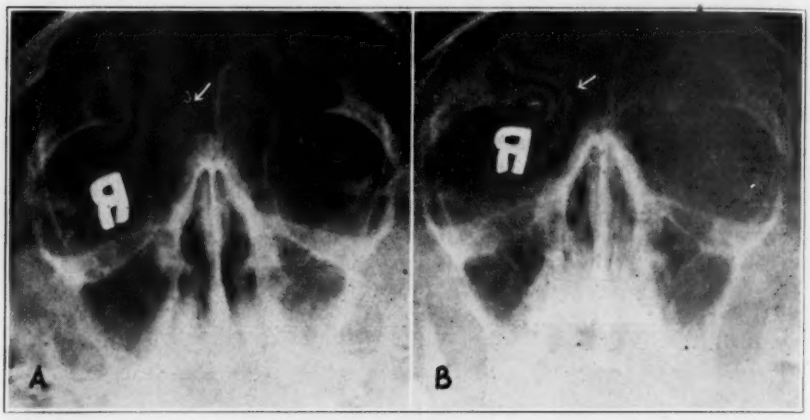

Fig. 4 (case 3).—*A*, roentgenogram showing a large round shadow in the right frontal sinus, representing a hematoma. *B*, roentgenogram made fifty-two days after the flight, showing almost complete clearing of the hematoma.

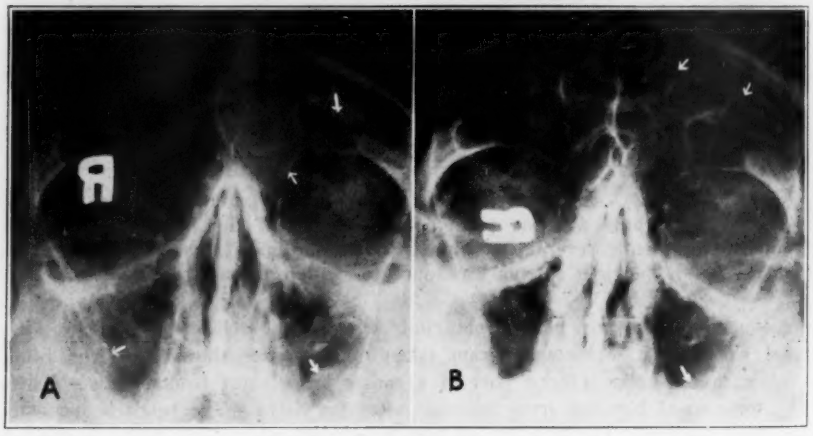

Fig. 5 (case 4).—*A*, roentgenogram showing a large round shadow in the left frontal sinus, representing a hematoma. *B*, roentgenogram taken forty-six days later, showing almost complete clearing of the left frontal sinus.

after the flight, showed a large round shadow in the median portion of the left frontal sinus, also a smaller rounded shadow at the lateral part of the left frontal sinus. The headache disappeared in several days. A roentgenogram taken forty-six days later showed almost complete absorption of the hematoma of the left frontal sinus. (See fig. 5.)

CASE 5.—On July 20, 1944 he was on a routine flight to 30,000 feet (about 9,000 meters) in the low pressure chamber. There was no difficulty on ascent. On descent he had a severe pain in the left frontal sinus region. This persisted intermittently for several hours. At the time of the flight there was stuffiness in the left side of his nose from a cold. The past history revealed no evidence that he had sinusitis and that he had flown about two hundred hours at high altitudes as an aerial photographer. On examination several days after the flight there was

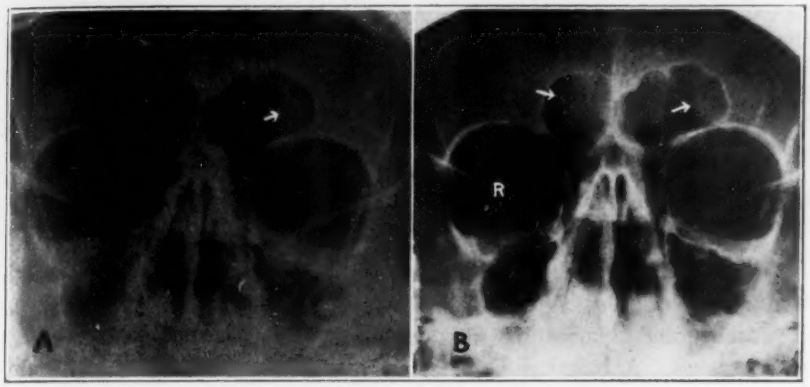

Fig. 6 (case 5).—*A*, roentgenogram showing a round shadow in the left frontal sinus, *B*, roentgenogram taken some days later, showing a large round shadow in the right frontal sinus as well as the original shadow in the left frontal sinus.

Fig. 7 (case 6).—*A*, roentgenogram showing a large round shadow in the right frontal sinus. *B*, roentgenogram made thirty-three days later, showing almost complete clearing.

marked congestion of the left side of his nose. Roentgen examination four days after the flight showed a small round shadow at the lateral margin of the left frontal sinus. There was slight thickening of the mucosa of the left antrum. Otherwise the sinuses were clear. On August 4 he made another flight in the low pressure chamber without the slightest difficulty. On August 15 the roentgeno-

grams showed a round shadow in the right frontal sinus. The shadow in the left frontal sinus remained unchanged (twenty-five days after the flight).

Comment.—The patient was not aware of any additional trauma from the second flight. Between July 24 and August 15 there were no roentgen studies; so the exact time of appearance of the second shadow on the opposite side is not known. Inasmuch as there were no symptoms on the second flight it is probable that the hematoma on the right occurred during the first flight but was delayed in appearance. (See fig. 6).

CASE 6.—The patient when seen on Aug. 1, 1944 complained of pain in the right frontal sinus region. The day before, he had experienced pain on descent in the low pressure chamber. Shrinking of the nasal mucosa relieved the pain. He had a cold at the time of the flight. Examination of the nose gave essentially negative results. There was good space on the right side. No blood or pus was seen. Roentgenograms showed a large round shadow in the right frontal sinus. The remaining sinuses were clear. By September 5 the sinuses showed complete clearing. (See fig. 7).

SUMMARY

Twelve cases of hematoma of the sinuses have been analyzed as to frequency, location, symptoms, mechanism of production, pathologic appearance and treatment of this condition. The term "aerohematoma" is suggested. Aerohematoma is a relatively new and interesting entity and is a rather uncommon finding associated with aerosinusitis.

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OTITIS MEDIA

A Comparative Study of the Results Obtained in Therapy Before and After the Introduction of the Sulfonamide Compounds

HOWARD P. HOUSE, M.D.
LOS ANGELES

IN AN attempt to evaluate the effects of sulfonamide compounds used in the treatment of otitis media, the records of all patients with this disease admitted to the Los Angeles County General Hospital during the fiscal years of 1935 and 1943 were reviewed.

Only those cases of otitis media in which the ear had drained for three days or longer were accepted in this series. This period of drainage was considered to establish with certainty the diagnosis of true purulent otitis media.

1935 SERIES (BEFORE THERAPEUTIC USE OF SULFONAMIDE COMPOUNDS)

This series was selected in order that the results of therapy before the general use of sulfonamide compounds began might be studied.

In 1935 the admissions to the Los Angeles County General Hospital totaled 53,411. Of these, 3,212, or 6.0 per cent, were admissions to the department of otolaryngology of the hospital.

Altogether, 2,189 case histories with the diagnosis of otitis media, from all departments, were reviewed in the 1935 series. This represents 4.0 per cent of the total admissions to the hospital.

In 1,369, or 66.6 per cent, of the 2,189 cases in which the diagnosis was otitis media the ear drained over the three day period. Therefore, in 820, or 33.4 per cent, of the 2,189 cases the ear either did not drain or drained less than three days.

Of the 1,369 acceptable cases, 1,241, or 91.1 per cent, were instances of acute, and 128, or 8.9 per cent, were instances of chronic otitis media.

Acute Otitis Media.—Of the 1,241 patients with acute otitis media, 671, or 54.1 per cent, recovered spontaneously, and 570, or 45.9 per cent, required simple mastoidectomy.

The duration of drainage in the nonsurgical cases is shown in table 1. Drainage ceased in 54 per cent of the cases within two weeks.

This study was presented as a candidate thesis to the American Laryngological, Rhinological and Otological Society in 1945.

From the departments of otolaryngology of the University of Southern California and the Los Angeles County General Hospital.

The duration of drainage before mastoidectomy is shown in table 2. In 58 per cent of the cases requiring mastoidectomy the operation was performed during the first two weeks.

The duration of postoperative drainage is shown in table 3. Eighty per cent of the ears operated on drained less than four weeks after surgical treatment. The majority ceased draining during the third postoperative week.

TABLE 1.—*Duration of Drainage in Nonsurgical Cases of Acute Otitis Media*

Drainage	Cases	Percentage
Less than 1 week	8	2.1
Less than 2 weeks	193	52.0
Less than 4 weeks	130	35.0
Less than 6 weeks	25	6.9
Less than 8 weeks	6	2.4
Less than 4 months	6	2.0

TABLE 2.—*Duration of Drainage Before Mastoidectomy in Cases of Acute Otitis Media*

Drainage	Cases	Percentage
Less than 1 week	66	17.5
Less than 2 weeks	153	40.7
Less than 4 weeks	95	25.2
Less than 6 weeks	38	10.1
Less than 8 weeks	18	4.9
Less than 4 months	6	1.5

TABLE 3.—*Duration of Postoperative Drainage in Cases of Acute Otitis Media*

Drainage	Cases	Percentage
Less than 2 weeks	135	33.9
Less than 4 weeks	183	46.3
Less than 8 weeks	49	12.4
Less than 4 months	19	4.9
Over 6 months	8	2.0
Over 1 year	1	0.25

Bacteriologic Findings in Cases of Acute Otitis Media.—Accurate bacteriologic data were available in 639, or 46.6 per cent, of the cases. The organisms noted are listed in table 4.

Chronic Otitis Media.—Of the 128 cases of chronic otitis media in this series, 70, or 54.6 per cent, required radical mastoidectomy. The duration of the postoperative drainage in these cases is shown in table 5.

Complications.—Complications were present in 489, or 35.5 per cent, of the 1,369 acceptable cases. Of these 489 cases, 441, or 90.2 per cent, were instances of acute, and 48, or 9.8 per cent, were instances of chronic, otitis media. The complications noted are listed in table 6.

Mortality.—Of the 1,369 accepted cases of otitis media, 74, or 5.4 per cent, were fatal. Of the 74 fatal cases, 59, or 79.7 per cent, were cases of acute, and 15, or 20.3 per cent, were cases of chronic, otitis media. The causes of death are listed in table 7.

TABLE 4.—*Organisms Noted in 1935 Series*

Organisms Cultured	Cases	Percentage
Hemolytic streptococci	319	49.9
Staphylococcus aureus	213	33.3
Pneumococci	36	5.7
Mixed streptococci	22	3.4
Diphtheroid bacilli	18	2.8
Streptococcus viridans	15	2.3
Klebs-Löffler bacillus	10	1.5
Bacillus coli	10	1.5
Tubercle bacillus	3	0.45
Bacillus proteus	1	0.15
Friedländer's bacillus	1	0.15

TABLE 5.—*Duration of Postoperative Drainage in Cases of Chronic Otitis Media*

Drainage	Cases	Percentage
Less than 1 month	9	18.3
Less than 3 months	17	34.6
Less than 6 months	11	22.4
Less than 1 year	12	24.4

TABLE 6.—*Complications Noted in 1935 Series*

Complication	Cases of Acute Otitis Media	Cases of Chronic Otitis Media
Subperiosteal abscess	136 (30.8%)	0
Recurrent acute mastoiditis	87 (19.7%)	0
Meningitis	44 (9.9%)	12 (25.0%)
Acute exacerbation of chronic otitis	42 (9.5%)	0
Thrombosis of lateral sinus	28 (6.3%)	0
Septicemia	22 (4.9%)	0
Perisinal abscess	21 (4.7%)	0
Facial palsy	20 (4.5%)	5 (10.4%)
Petrositis	16 (3.6%)	1 (2.0%)
Labyrinthitis	6 (1.3%)	0
Abscess of brain	5 (1.1%)	7 (14.5%)
Bezold's abscess	4 (0.90%)	0
Extradural abscess	4 (0.90%)	0
Masked mastoiditis	3 (0.68%)	0
Cholesteatoma	0	20 (41.6%)
Carcinoma of cavity	0	2 (4.1%)
Acute postoperative shock	0	1 (2.0%)

TABLE 7.—*Causes of Death in Fatal Cases in 1935 Series*

Cause of Death	Cases of Acute Otitis Media	Cases of Chronic Otitis Media
Meningitis	41 (69.5%)	9 (60.0%)
Thrombosis of lateral sinus	7 (11.8%)	0
Abscess of brain	5 (8.4%)	5 (33.3%)
Septicemia	3 (5.0%)	0
Petrositis	2 (3.2%)	0
Labyrinthitis	1 (1.6%)	1
Postoperative shock	0	1 (6.6%)

1943 SERIES (AFTER THERAPEUTIC USE OF SULFONAMIDE COMPOUNDS)

This series was selected in order that a study might be made of the results of therapy after the start of the general use of sulfonamide compounds.

In 1943, 45,434 persons were admitted to the Los Angeles County General Hospital. Of these, 1,221, or 2.6 per cent, were admitted to the department of otolaryngology of the hospital.

Altogether, 1,137 case histories with the diagnosis of otitis media, from all departments, were reviewed in the 1943 series. This represents 2.2 per cent of the total admissions.

In 230, or 20.3 per cent, of the 1,137 cases in which the diagnosis was otitis media the ear drained over the three day period. Therefore, in 907, or 79.7 per cent, of the 1,137 cases the ear either did not drain or drained less than three days.

TABLE 8.—*Duration of Administration of Sulfonamide Compounds in Cases of Acute Otitis Media*

Duration	Cases	Percentage
Less than 5 days	29	24.7
Less than 8 days	57	47.7
Less than 11 days	9	7.6
Less than 14 days	10	8.5
Over 14 days	12	10.2

Of the 230 acceptable cases, 193, or 83.9 per cent, were instances of acute, and 37, or 16 per cent, were instances of chronic, otitis media.

Acute Otitis Media.—Of the 193 patients with acute otitis media, 159, or 82.4 per cent, recovered spontaneously, and 34, or 17.6 per cent, required simple mastoidectomy.

The duration of the administration of sulfonamide compounds is shown in table 8. In 72 per cent of the cases the sulfonamide compounds were administered for less than eight days.

The duration of drainage in the nonsurgical cases is shown in table 9. Three fourths of the ears stopped draining within two weeks. Five per cent drained over four weeks.

The duration of drainage before mastoidectomy is shown in table 10.

Fifty-four per cent of the patients requiring surgical treatment were operated on during the first week, and 7.6 per cent were operated on after four weeks of drainage of the diseased ear.

The duration of postoperative drainage is shown in table 11. Ninety-two per cent of the ears operated on drained less than four weeks after surgical treatment. The majority ceased draining during the second postoperative week.

Bacteriologic Findings in Cases of Acute Otitis Media.—Accurate bacteriologic data were available in 51, or 22.1 per cent, of the cases. The organisms noted are listed in table 12.

TABLE 9.—*Duration of Drainage in Nonsurgical Cases of Acute Otitis Media*

Drainage	Cases	Percentage
Less than 1 week	55	37.4
Less than 2 weeks	59	40.1
Less than 4 weeks	25	16.9
Less than 6 weeks	6	4.0
Less than 8 weeks	2	1.3

TABLE 10.—*Duration of Drainage Before Mastoidectomy in Cases of Acute Otitis Media*

Drainage	Cases	Percentage
Less than 1 week	5	15.3
Less than 2 weeks	10	38.4
Less than 4 weeks	10	38.4
Less than 6 weeks	1	3.8
Less than 8 weeks	1	3.8

TABLE 11—*Duration of Postoperative Drainage in Cases of Acute Otitis Media*

Drainage	Cases	Percentage
Less than 2 weeks	14	53.7
Less than 4 weeks	10	38.4
Less than 8 weeks	1	3.8
Over 1 year	1	3.8

TABLE 12.—*Organisms Noted in Cases of Acute Otitis Media*

Organisms Cultured	Cases	Percentage
Hemolytic streptococci	22	43.1
Staphylococcus aureus	15	29.4
Pneumococci	9	17.6
Streptococcus viridans	3	5.7
Mixed streptococci	1	1.9
Bacillus proteus	1	1.9

TABLE 13.—*Duration of Postoperative Drainage in Cases of Chronic Otitis Media*

Drainage	Cases	Percentage
Less than 1 month	4	25.0
Less than 3 months	9	56.2
Less than 6 months	1	6.2
Over 1 year	2	12.4

Chronic Otitis Media.—Of the 37 patients with chronic drainage of the ear in this series, 22, or 59.0 per cent, underwent radical mastoidectomy. The duration of postoperative drainage in these cases is shown in table 13.

Complications.—Complications were present in 63, or 28.6 per cent, of the 230 acceptable cases. Of these 63 cases, 49, or 77.7 per cent, were cases of acute, and 14, or 22.2 per cent, were cases of chronic, otitis media. The complications noted are listed in table 14.

Mortality.—Of the 230 accepted cases of otitis media, 12, or 5.2 per cent, were fatal. In 7 of the 12 fatal cases, meningitis was the

TABLE 14.—*Complications Noted in 1943 Series*

Complication	Cases of Acute Otitis Media	Cases of Chronic Otitis Media
Subperiosteal abscess	17 (34.6%)	2 (14.2%)
Meningitis	12 (24.0%)	1 (7.1%)
Acute exacerbation of chronic otitis	8 (16.3%)	0
Thrombosis of lateral sinus	4 (8.0%)	1 (7.1%)
Septicemia	4 (8.0%)	0
Recurrent mastoiditis	2 (4.0%)	2 (14.2%)
Facial paralysis	1 (2.0%)	0
Other complications	1 (2.0%)	0
Petrositis	0	1 (7.1%)
Cholesteatoma	0	7 (50.0%)

TABLE 15.—*Causes of Death in Fatal Cases of 1943 Series*

Cause of Death	Cases of Acute Otitis Media	Cases of Chronic Otitis Media
Thrombosis of lateral sinus	2 (36.0%)	0
Meningitis	1 (18.0%)	0
Abscess of brain	1 (18.0%)	0
Septicemia	1 (18.0%)	0
Petrositis	1 (18.0%)	0

cause of death, and in 6 of these the patient died before being treated with sulfonamide compounds and before mastoidectomy could be performed. If these 6 cases are disregarded, as they should be, the number of fatal cases changes from 12 to 6, with a mortality rate of 2 per cent. The causes of death are listed in table 15.

ANALYSIS OF STATISTICAL DATA

Admissions to Hospital.—It is interesting to note a 15 per cent decrease in the total number of persons admitted to the hospital in 1943, notwithstanding a marked increase in the population of the county. Obviously, the explanation rests with improved financial means.

Admissions to the Department of Otolaryngology.—There was a 66 per cent decrease in the number of persons admitted to the department of otolaryngology in 1943 as compared with 1935; likewise, a decrease of 50 per cent in the number admitted with otitis media. The sharp decrease in total number of admissions may be partially accounted for

by the reduced number of cases in which tonsillectomy was required. However, the decrease in the admissions of patients with otitis media is significant and strongly suggestive of a direct influence of sulfonamide drugs.

Acceptable Cases of Otitis Media.—In 1935, 2 of 3 ears whose condition had been diagnosed as otitis media drained over a three day period. In 1943, only 1 of 5 drained over a three day interval. This suggests that the use of sulfonamide compounds, if instituted at the onset of acute otitis media, may abort further progress of the disease.

Incidence of Acute and Chronic Otitis Media.—This study indicates little difference in the incidence of acute and chronic otitis media. In the future the incidence of chronic otitis media should decrease considerably under the influence of sulfonamide compounds.

Incidence of Mastoidectomy in Cases of Acute Otitis Media.—In the 1935 series, nearly half of all the patients with acute otitis media admitted required mastoidectomy. In 1943, following the use of sulfonamide compounds, the proportion requiring surgical intervention was reduced to less than 1 in 5.

Duration of Drainage in Nonsurgical Cases.—In the 1935 series the average patient with acute otitis media recovered spontaneously between the second and the third week. In patients treated with sulfonamide drugs, drainage ceased between the first and the second week.

Duration of Drainage Before Mastoidectomy.—In the majority of cases in the 1935 series, the duration of preoperative drainage was less than two weeks. Under treatment with sulfonamide compounds the period was slightly less than three weeks.

Duration of Postoperative Drainage.—In the majority of cases in the 1935 series, the duration of postoperative drainage was three weeks. In the 1943 series the average period was approximately two weeks.

Bacteriologic Findings.—In a bacteriologic comparison little difference in the two series was noted. Str. haemolyticus, Staph. aureus and Pneumococci were the predominating organisms.

Surgical Intervention in Chronic Otitis Media.—It is interesting to note that the incidence of radical mastoidectomy is essentially the same in the two series. The greater number of patients in each series obtained a dry ear in the third postoperative month. In the 1943 postoperative group one-half as many of the ears were draining one year after operation as in the 1935 postoperative group.

Complications.—The number of cases of acute otitis media in which complications occurred was 20 per cent less under the influence of treatment with sulfonamide compounds. The number of cases of chronic

otitis media with complications in the 1943 series was sharply increased. This fact is difficult to explain. A comparison of the incidence of the various complications in the two series is of interest.

Mortality.—The 1935 series carried a mortality rate of 5.4 per cent. Under therapy with sulfonamide compounds the mortality rate was reduced to 2.6 per cent.

The most startling effect of sulfonamide compounds was observed in otitic meningitis. In the 1943 series there were 13 cases of otitis media in which meningitis developed. In 6 of these sulfonamide compounds were not used, and therefore these 6 cases are eliminated in the study of mortality. Of the remaining 7 cases, 1 case, or 14.3 per cent, was fatal. In the 1935 series there were 56 cases of otitis media in which meningitis developed. Of these, 50, or 89.4 per cent, were fatal.

SUMMARY AND CONCLUSIONS

A review of 3,326 case histories of patients hospitalized because of otitis media before and after the general therapeutic use of sulfonamide drugs began elicits the following information:

1. The number of patients hospitalized because of otitis media has decreased by 50 per cent.

2. In 4 of 5 patients with acute otitis media the pathologic process can be arrested within three days if the administration of sulfonamide compounds is instituted at the onset of symptoms.

3. The incidence of mastoidectomy in patients hospitalized because of acute otitis media has been reduced by two thirds.

4. Spontaneous recovery occurs one week earlier in patients with acute otitis media who are treated with sulfonamide compounds.

5. Surgical intervention was necessary approximately one week earlier when sulfonamide compounds were not administered.

6. Postoperative drainage has been lessened by one week.

7. The incidence of complications in cases of acute otitis media has been reduced by 20 per cent.

8. The mortality rate of otitic complications has been reduced by one half.

9. Before the advent of sulfonamide compounds as therapeutic agents, 9 of 10 persons with otitic meningitis died; with the therapeutic use of sulfonamide compounds the rate is 1.5 to 10.

This analysis strongly encourages the use of adequate doses of a sulfonamide compound beginning with the onset of symptoms of acute otitis media.

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EXCISION OF SUPERIOR MAXILLA AND ETHMOID LABYRINTH

SURGEON COMMANDER E. R. G. PASSE, F.R.C.S., R.N.V.R.

DURING the last decade the progress of surgical technic in rhinolaryngology has been rapid, but there is now a tendency toward ultraconservatism in certain fields, notably that of the nasal cavity and the adjacent air sinuses. Conservatism has sometimes proved most laudable in chronic infective conditions of this area, but the pendulum has swung too far, with the result that many patients who should be treated by surgical methods are now dealt with in a conservative manner.

The adoption of this attitude is largely due to the fact that a large number of bad results have been observed in the past in consequence of ineffectual surgical treatment and to the fact that many new-fangled ideas and drugs have been introduced, eagerly seized on, used for a time and finally discarded. As pointed out by me [1] in 1938, too much reliance has been placed on the claims, sometimes unwittingly exaggerated, of radiotherapeutists as to the treatment of cancerous and even chronic infective conditions of the sinuses. The situation is so confused today that one is apt to forget the teachings of his forebears in rhinology who found, before the days of irradiation, sulfanilamides, estrogens, androgens and so forth, that surgical methods were frequently satisfactory. Yesterday it was chemotherapy; today it is water balance; tomorrow it may be something else. These claims often mislead the younger rhinologist into believing that surgery is now a back number in the treatment of cancerous and chronic infective diseases of the sinuses, with the result that he never has the opportunity of developing the necessary operative technic.

I

EXCISION OF THE MAXILLA—A HISTORICAL SURVEY OF THE OPERATION

Although, for the reasons stated, extensive operations on the upper jaw have largely gone out of favor, the indications for partial or complete removal have undergone little alteration; they are necrosis, myeloma (osteoclastoma), osteitis fibrosa (fibrous osteoma—K. C. Eden,[2] 1939), sarcoma and carcinoma. In the two last-named conditions it is probable that the most beneficial treatment if the cancer is

1. Passe, E. R. G.: Brit. M. J. **1**:1231-1232, 1938.
2. Eden, K. C.: Brit. J. Surg. **27**:323-350, 1939.

operable, i. e., one which has not spread beyond the limits of the bone into the cheek or backward into the sphenomaxillary fissure, is a combination of diathermy excision and irradiation. The decision as to whether a formal resection of the jaw shall be undertaken, as against partial removal by Moure's or Norman Patterson's method of approach, must depend on the site and the extent of the area involved.

Up to the present time the results of these operations, though excellent so far as eradication of the disease is concerned, have nearly always been accompanied by most distressing deformities of the face and defects of speech and mastication. The late Sir St. Clair Thomson [3] (1916) in describing the operation for excision of the upper jaw, used the following quotation from "Macbeth"—"a most bloody piece of work"—but, with adoption of the technic which I shall describe, this quotation is happily no longer applicable.

For the reasons already referred to, many patients with operable cancer of the upper jaw have been transferred for treatment to radiotherapeutists, and the results in comparison with those of surgical excision do not justify this transfer.

Historical Review.—A hundred years ago few patients suffering from nasal obstruction, purulent discharge or epistaxis sought advice; hence those suffering from cancer of the nose were seldom examined until the disease had invaded the mouth, the orbit or the face. The surgeon, therefore, had no alternative but to attempt some extensive and disfiguring operation. It is interesting to note that with the passage of time and the improvement of technic operations became less and less mutilating. Many names, famous in the annals of surgery and anatomy, are attached to these operations.

The earliest record of excision of the maxilla appears to be in 1693 when Acolthus extirpated from the upper jaw a tumor having the character of an enchondroma, through an incision passing upward across the cheek from the corner of the mouth.

In 1784 Franz of Nuremburg, Germany, excised a "fongus" of the upper jaw with the aid of an instrument in the form of a spatula. In 1789 Desault excised an upper jaw because of a sarcoma. In 1827 Dupuytren partially excised the upper jaw because of a sarcoma, after ligating the common carotid artery. The patient, however, died, and ligation of the common or the external carotid artery in connection with this operation was apparently not attempted again for many years. In 1827 Lizars, of London, and Gensoul, of Paris, France, performed the operation several times. In 1829 Lisfranc performed a modified excision, the result of which is unrecorded. In 1830 Syme, of Edinburgh, Scotland, performed the operation and recommended an incision

3. Thomson, St. C.: Lancet **1**:987, 1916.

"commencing at the angle of the mouth and extending upwards to the middle of the malar bone." He operated in this manner on six occasions. The obvious objection to this incision was that it cut through the facial artery, a branch of the facial nerve, Stensen's duct and the orbicularis oculi and the orbicularis oris, resulting in paralysis of these muscles and in a salivary fistula. From America came a description of an operation performed by Warren, of Boston, in 1838. In 1842 Huguier advised commencing the incision more medially and carrying it upward to the anterior border of the malar bone (fig. 1 *A*). However, Stensen's duct was not always saved. The advantage claimed from this incision was greater accessibility, especially in the cases in which the malar bone was involved.

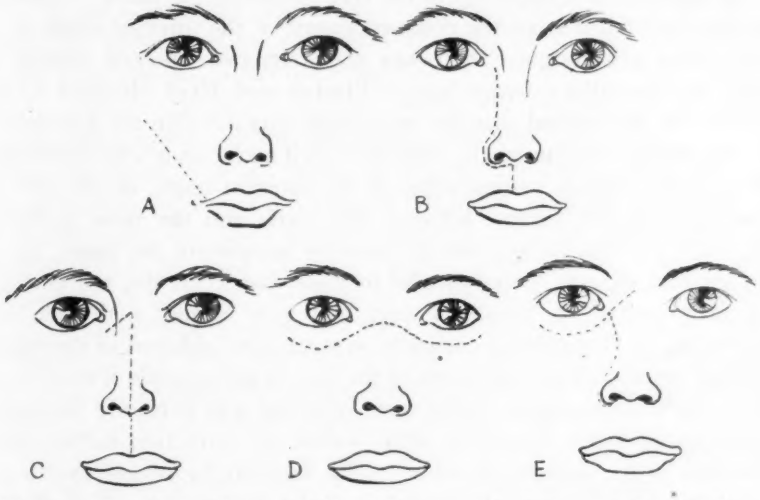

Fig. 1.—Historical review of incisions for removal of the superior maxilla: *A*, Hugier's (1842). *B*, Fergusson's (1842). *C*, incision practiced by Langenbeck and Roux in 1850, also by Dieffenbach in the same year. *D*, Heyfelder's incision for removal of both superior maxillas (1856). *E*, Heyfelder's "anterior lateral incision" (1858).

Fergusson[4] (1842), of King's College Hospital, described an excision of the superior maxilla (fig. 1 *B*) for a supposed osteosarcoma in a young girl aged 12 years:

The patient having been seated on a strong chair Mr. Fergusson commenced the operation by entering the bistoury just below the tendon of the orbicularis palpebrarum, the knife was then carried down by the side and round the ala of the nose. The incision then terminated by the lip being transfixed a little to the left of the medial line, the bistoury was now passed within the mouth and through the central fibres of the masseter muscle and was then drawn rapidly down to the angle of the mouth. The eye, with the soft parts surrounding it, was separated

4. Fergusson: Prov. M. & S. J. **3**:440-441, 1842.

from the floor of the orbit with the flap held up by an assistant. . . . The patient was then placed upon the operating table, the cavity sponged out, and five vessels secured; the haemorrhage having been arrested, the cavity was stuffed with lint and the patient carried back to bed. The operation, which was borne with great fortitude, lasted 16 minutes. Suppuration commenced on the fifth day and on the seventh day the pulse, which had ranged between 120 and 130, descended to 112. On the 12th day the child was permitted to eat some chicken for dinner and she is now nearly convalescent.

In 1850 Langenbeck and Roux performed the operation several times. Dieffenbach in 1850 used the following incision in cases in which the bone was but little swollen and the soft tissues of the cheek were healthy (fig. 1 *C*): A median incision was made, commencing above and between the eyebrows, and was carried downward along the middle of the nose and the upper lip to the free border of the latter. A second incision was made from the commencement of the internal angle of the eye. This quadrangular flap was then stripped upward, laying the nasal and maxillary bones bare. Blasius and Reid objected to this incision on the ground that the nasal edge was too thin for nutrition.

Heyfelder,[5] of Munich, in 1858 described an incision which he termed the anterior lateral, commencing at the internal angle of the eye and passing down the furrow between the cheek and the nose to the ala (fig. 1 *E*). This incision cut the elevator muscles of the upper lip and the ala nasi in a direction parallel to their fibers. It did not endanger the facial nerve or Stensen's duct and gave a less noticeable scar. According to Heyfelder, a complete subcutaneous ablation of the maxilla without incision of the soft parts of the face is not possible if there is any but a slight enlargement of the bone or if the soft parts are involved—"such an operation would be better called an extraction rather than a resection of the maxilla superior." The incision, he stated, can be prolonged upward between the eyebrows if the growth extends to the root of the nose; or, if the growth necessitates the excision of the zygomatic process, one can add an incision from the point of commencement outward for a varying extent along the crease between the lower eyelid and the cheek. Heyfelder warned against extending this incision farther than necessary, owing to the risk of subsequent edema of the lid. An interesting note on the operative procedure employed by this surgeon is that he advised the operator to pause after the soft parts had been dealt with in order to fortify the patient with a glass of wine or water. It was not apparently the practice at this stage to tie the external carotid artery. Severe hemorrhage often needed the application of a cauterizing iron, and frequently erysipelas followed as a complication. It was also advised that the flaps should not be sutured for four to five hours in

5. Heyfelder, O.: Traité complet de la résection des maxillaires supérieurs, Paris, F. Chamerot, 1858.

order to make sure that hemorrhage had ceased. The filling of the cavity with packing or rubber was advised against, as it augmented inflammation and the collection of pus.

In those days operations of this kind must indeed have been most formidable. Of the 15 patients on whom Heyfelder operated, mostly elderly people, the majority died within a few hours, or lived a few days at the most. Hemorrhage, local gangrene and thoracic complications seem to have been the eliminating factors. It is interesting to note that union of the edges of the incision by primary intention was the rule. Those patients that survived for a period of weeks were pronounced cured, although Heyfelder recorded that in 1 case of excision for sarcoma the patient was still alive after "several years."

Langenbeck in the period from 1854 to 1856 operated on 6 patients, 5 of whom succumbed shortly after the operation; the result in the remaining patient, whose orbit was exenterated at the same time for orbital involvement, is not recorded. It is only fair to state, however, that of these 6 patients, all except 1 were over 60 years of age and all the operations were performed without an anesthetic.

An operation in which both maxillas were excised at the same time was described by Roger in 1824 and another by Liston in 1836. In 1844 Heyfelder described 3 cases in which bilateral excision was performed; 1 patient, aged 23, lived for five months. An account of this patient was given in the *Dublin Medical Journal* in February 1856, in an article entitled "The Resection of the Upper Yaw-Bones." The incision employed passed from one malar bone to the other across the cheek and over the bridge of the nose, following the curve of the nasojugal fold; the soft tissues were reflected downward (fig. 1 *D*).

Paget is also stated to have performed a resection of both maxillas and nasal bones for a tumor involving the root of the nose.

Michaux and Heyfelder in 1858 compiled the following statistics of 112 cases in which a single maxilla and 9 cases in which both maxillas were excised: 50, results favorable; 30, patients died soon afterward; 41, results unknown. Reading the accounts of these early operations one cannot help but admire the fortitude of the patient and the courage of the surgeon.

TRANSORAL APPROACH (ILLUSTRATED IN A CASE OF OSTEITIS FIBROSA OF THE MAXILLA)

Even up to the present time the approach for excision of the upper jaw advised in surgical textbooks is the method employed by Fergusson [4] in 1842. I should like to present a new approach, illustrated by a case. This, despite the view of Heyfelder to the contrary in 1858, I believe should be the method of choice in all cases except those in which the skin of the cheek is involved, and even then some modification of the

technic about to be described may be used. If an external incision is avoided, scar formation and contraction are reduced to a minimum.

J. M. aged 20, presented himself on Oct. 13, 1942 with a history of eight years' gradual increase in size of the right upper jaw. For the last six months there had been slight aching, chiefly at night, and some tenderness over the swelling. There was no visual disturbance, but nasal obstruction was present on the right side. The family history was not relevant. There had been no previous illnesses of note. Deglutition was normal, but articulation was imperfect owing to a swelling inside the mouth.

On examination there was a painless hard swelling in the region of the right cheek, extending laterally into the zygomatic process and into the right alveolar process and the hard palate. The bony swelling also protruded into the nose and nasal fossae and the mouth. The movements of the soft palate were normal. No

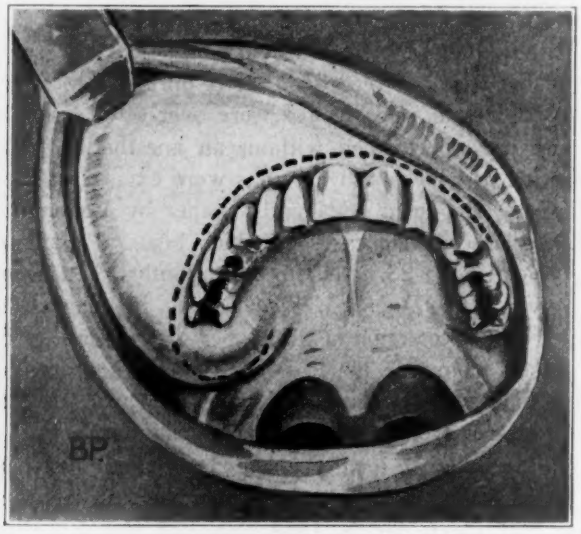

Fig. 2.—Author's incision.

nasal discharge was present, and there was no area of anesthesia or hyperesthesia. Movements of the eyeball were normal in all directions. Roentgen study of the sinuses revealed diffuse opacity of the right antrum and an enlargement of the maxilla, the malar bone and the alveolar process extending on to the hard palate. A section was taken on October 16, and the pathologic report from Dr. W. W. Woods, consulting pathologist to the Royal Navy, was as follows:

"The specimen consists of the alveolar process and part of the palatine process of the left maxilla. Part of the floor of the maxillary antrum is included on the upper surface of the specimen; its lining is smooth. The bone is diffusely enlarged and feels heavy (weight, 71.1 Gm.); the enlargement is uniform, so that the normal contour of the bone is to a large extent preserved. Its concave inner surface shows the smooth lining of the lateral wall of the nasal cavity. The mucous membrane of the gum and the part of the palatal mucous membrane that is present are smooth and white. Five healthy teeth are in situ, second incisor, canine, first

premolar and first and second permanent molars; there is a healed gap at the site of the absent second premolar; the unerupted third molar is seen in a roentgenogram. When the specimen has been coronally bisected with a saw through the site of the absent premolar (fig. 3), the cut surfaces are flat and hard, and are partly occupied by pale gray to almost white areas of a type of bone which under a hand lens differs from ivory bone in being beset with minute granules; these areas merge into a dark gray coarser granular bone. The granularity is caused by the bulging from pores of a tissue which is soft but tough to the point of the knife. A cortical structure is recognized only in the lower third of the wall of the nasal cavity, and is extremely thin. At this section the cut surfaces are 3 to 3.3 cm. from within out and from above down.

"Microscopic examination: A slice was taken to include the whole specimen at the bisecting cut; it was transferred from a 4 per cent solution of formaldehyde (solvent isotonic solution of sodium chloride) to Müller's fluid for two months,

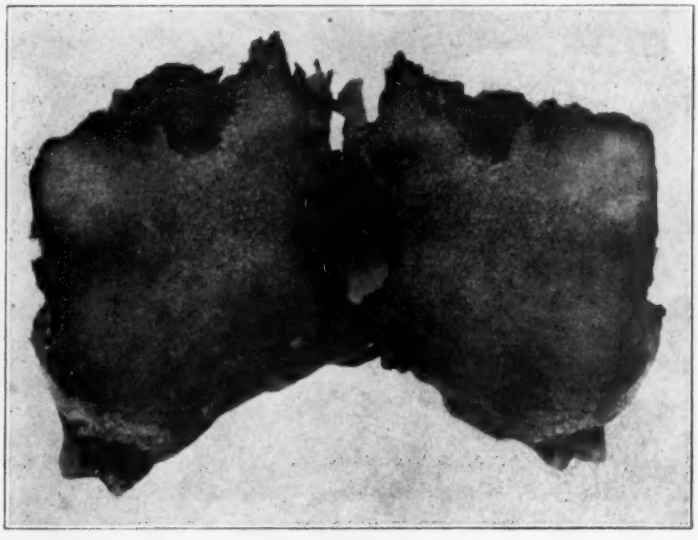

Fig. 3.—Cut surfaces of a coronal section of the specimen removed in the case reported.

decalcified in 3 per cent formic acid in a 4 per cent solution of formaldehyde (solvent, isotonic solution of sodium chloride) and embedded in celloidin (a concentrated preparation of pyroxylin). Sections were stained with Ehrlich's hematoxylin and eosin and with Weigert's iron-hematoxylin and Van Gieson's mixture and by Schmorl's thionine method. The dark, coarsely granular areas seen macroscopically correspond to moderately wide but occasionally stout or slender, irregularly branched and occasionally anastomosing trabeculae of bone in an abundant matrix of fibrotic marrow composed of collagen fibers and spindle fibrocytes, which contains well formed arterioles and wide and narrow capillaries (fig. 4*A*). In a few small foci it is rarefied, resembling a jelly tissue, the fibrils being very slender, sparse and indistinct. In the pale, finely granular areas seen macroscopically the trabeculae are more numerous, smaller, more branched, more slender and anastomose more frequently, while collagen fibers are scanty and more

delicate, and the spindle cells are numerous, less elongated and closely packed but uniform in appearance (fig. 4 *B*). In both the dense and the more cellular marrow there is a slight infiltrate of lymphocytes and plasma cells, and there are few groups

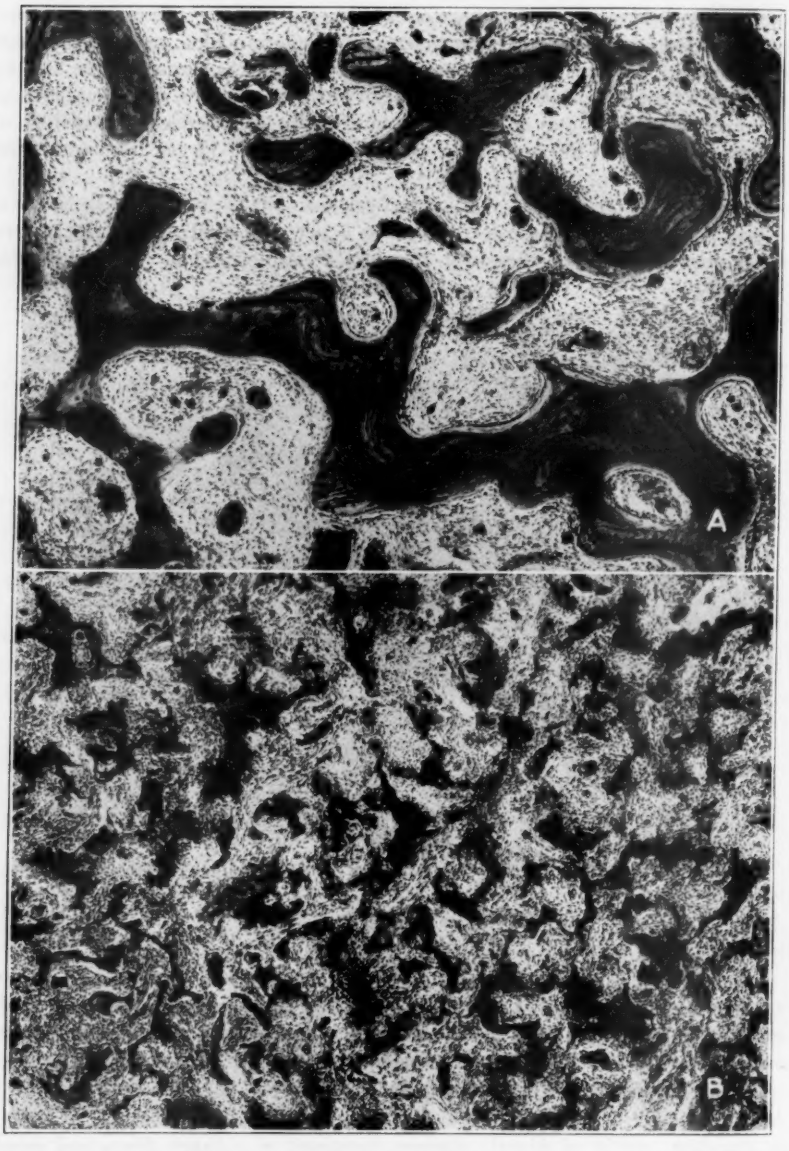

Fig. 4—*A*, area dark in figure 3. *B*, area pale in figure 3. Hematoxylin and eosin; × 43.

of large foamy macrophages. The cellular areas of the fibrous marrow occupy chiefly the part of the cut surface next the external aspect of the jaw, excepting a narrow zone beneath this outer surface. In this zone the trabeculae are at their

stoutest and frequently show exceptionally numerous haversian systems. The slender trabeculae in the cellular marrow consist chiefly of woven bone, while the stouter trabeculae are usually entirely lamellar. Active deposition of bone is greatly in excess of osteoclastic absorption. It is greatest in the cellular fibrous marrow. Where the osteoid seams are cut at right angles to the trabeculae, their depth is within normal limits. Osteoclastic absorption is shown by osteoclasts in lacunas and is also greater where the fibrous marrow is cellular. The areas of cellular fibrous marrow are the areas of the greatest and most recent activity.

"I am indebted to Mr. John King for the preparation of the sections, the photograph and the photomicrograph."

As the condition involved the zygoma and the nasal fossa as well, it was felt that simple scraping of the bone would not alleviate the deformity or relieve the condition; complete excision was therefore determined on. To my knowledge and experience, when such a condition is dealt with by Moure's [6] or Fergusson's [4] incision the results include a gross contraction of the cheek, transitory edema of the lower eyelid and keloid formation along the scar, especially at the side of the nose. I therefore determined to adopt an entirely intraoral approach.

Preparation.—Little preparation was required beyond the making of a plaster mold of the face and upper jaws, from which the dental surgeon constructed a temporary obturator, complete with teeth, approximately the same size as the sound jaw. This obturator was inserted twenty-four hours after the operation.

Anesthesia.—After the usual premedication, the patient was anesthetized with nitrous oxide, oxygen and ether, administered by means of a nasoendotracheal tube passed down the opposite side, leaving the right side of the nose and the mouth free.

Operation.—The external carotid artery was then tied (in situ) and the neck wound closed. The upper lip was widely retracted by the assistant, and an incision was made down to the bone through the mucoperiosteum covering the alveolus, commencing in the gum about ⅛ inch (3 mm.) above the neck of the first premolar tooth on the sound side, and was carried round the alveolus on the affected side at the same level and round the back of the tuberosity and on to the palate, and from there across to the midline at the junction of its hard and soft components. After extraction of the right central incisor the mucoperiosteum of the hard palate was divided in the midline from before backward, to join the end of the first incision. The mucoperiosteum of the alveolar margin was then separated upward together with the soft tissues, by means of a rongeur, to the extent found necessary. The curtain of mucoperiosteum so formed can be employed to help cover the raw surface of the cavity resulting from the operation. With suitable periosteum detachers and raspatories the soft tissues of the cheek, the nose and the alveolus were separated upward from the bone toward the inner angle of the eye and the infraorbital margin, and outward over the zygomatic process. With care and patience it was found that the soft tissues could be retracted to an amazing extent, and the maxilla, including the infraorbital margin and the malar bone, could be brought adequately into the field of operation. The frontal process of the maxilla could then be divided by means of bone forceps or a dental drill. A puncture wound was then made through the lower lid on to the floor of the orbit just below the external canthus, and with a small chisel a hole was made just inside the orbital margin and a probe passed downward and outward behind the malar bone and out through the oral cavity. To the end of this probe was attached a Gigli saw, one end of which was drawn up through the orbit; by using suitable metal retractors to protect the soft tissues of

6. Moure, E. J.: Rev. hebd. de laryng. **1**:401-407, 1902.

the orbit and the cheek, the malar bone was sawed through. Next, the hard palate was divided from before backward along the midline incision by means of a sharp cutting burr in a dental contra-angle hand piece. I found this much more convenient, and it cut more quickly, than the narrow keyhole saw. The bone remained attached only by the pterygoid process and the lateral mass of the ethmoid bone; the bony mass was grasped with lion forceps and removed by extraction as one would extract a molar tooth. The use of a Gigli saw to cut through the malar bone is by no means new; it was advocated by Heyfelder in 1850. In those days a

Fig. 5.—*A* and *B*, apparatus for fixing skin-covered temporary obturator in place. *C*, final obturator to prevent deformity. *D*, patient three months after excision of the right superior maxilla.

chain saw was used. In recent times Sir William Wheeler has employed a similar saw; it was used formerly, however, only after outward reflection of the cheek.

Hemorrhage was slight and did not require even the use of a sucker. Should there be any portion of the malar bone or the orbital margin left, it can be easily removed by means of suitable bone forceps. The mucous membrane, which

covered the alveolus, was turned upward and stitched by a few silk sutures to the soft tissues of the cheek to retain it in place. It was found that this mucoperiosteum covered a considerable amount of the raw area. The wound was then dusted with sulfanilamide powder and packed with petrolatum-impregnated gauze for forty-eight hours. There was very slight general reaction to the operation, and two days later the patient was given pentothal sodium while the temporary obturator was inserted. This was removed daily for lavage, and within ten days healthy granulations covered the area. On the twelfth day an intermediate thickness cutaneous graft from the anterior surface of the left thigh was applied over the obturator to the raw area. In order to get constant pressure of the obturator against the walls of the cavity it was necessary to evolve the retention apparatus shown in figure 5 *A* and *B*. This consisted of a plaster headband to which the obturator was attached by means of a connecting rod to the aluminum base plate previously inserted into the obturator. When the obturator was removed on the tenth day after insertion, the graft was found to be firmly adherent.

It now remained to fit a final obturator in order that the deformity might be overcome and mastication and deglutition restored to normal (fig. 5 *C*). This work was ably carried out by my dental colleague, Surgeon Lieutenant Commander Ferris, R. N., and Dr. Gibson, of Glasgow Dental Hospital, and the patient was returned to duty approximately three months after his admission, bearing almost no manifestation of the operation (fig. 5 *D*). Six months after the operation his speech is excellent, and there is no difficulty in deglutition or mastication.

II

EXCISION OF THE ETHMOIDAL LABYRINTH

This operation was performed in the early part of the last century in conjunction with partial or complete excision of the upper jaw in cases of cancer, but surgical excision of the ethmoid mass alone was not generally performed until Moure,[6] of Bordeaux, in 1902 developed the operation and published his article "Traitment des tumeurs malignes primatives de l'ethmoide." For this he used an incision which commenced on the side of the nose above the inner canthus of the eye and extended downward in the fold between the nose and the cheek to the lateral side of the nasal orifice. From the point of commencement of the incision, a second incision curving outward below the lower eyelid to the prominence of the malar bone was made, if it was found necessary to obtain a wider exposure. The triangular flap of cheek tissue thus formed was then turned downward and outward, and as much of the maxilla and the ethmoid bone was removed as was necessary. This incision, of course, is part of that devised by Fergusson (1842) for complete excision of the upper jaw. The disadvantage of this incision is well known, as edema of the lower eyelid generally occurs, due to lymphatic obstruction caused by the diversion of numerous lymphatic vessels in the outer half of the nasojugal fold. Moure realized this and modified his incision to the first portion along the side of the nose.

Sir St. Clair Thomson in 1916 gave an illustrated account of this operation, describing several cases, and spoke highly of it as a means of

approach in dealing with cancer arising in the nose or its adjoining sinuses. Until recently this was the approach of choice; now, however, a method has been evolved by Norman Patterson [7] (1939 and 1942) for chronic pansinusitis and polypoid degeneration which gives a perfectly adequate exposure of the ethmoid bone, the sphenoid bone and the medial wall of the maxilla and the antrum. The incision commences immediately below the medial palpebral ligament about 4 mm. from the inner canthus (the anterior facial vein lies from 6 to 8 mm. from the inner canthus) and then extends downward and outward for about 1 inch to 1¼ inches (2.5 to 3 cm.) in the nasojugal fold, i. e., the fold between the lower eyelid and the cheek. This incision has an advantage in that it runs parallel to Langer's lines in the skin and also to the fibers of the orbicularis oculi muscle. The fibers of the orbicularis oculi are separated in line with the cutaneous incision by blunt dissection, exposing to view the fascia lying over the lacrimal sac and the commencement of the lacrimal duct, and a portion of the orbital wall formed by the maxilla (fig. 6). By mobilization of the lower portion of the

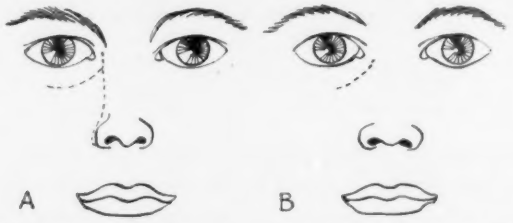

Fig. 6.—Incision for excision of the ethmoid labyrinth. *A*, Moure's incision. *B*, Norman Patterson's incision.

lacrimal sac and the duct, sometimes of its whole extent, a direct approach to the anterior, middle and posterior ethmoid cells, the sphenoid sinuses and the maxillary antrum is obtained. In order to mobilize the lacrimal sac with its duct and displace it outward, a portion of the upper and inner angle of the maxillary antrum is excised, care being taken, of course, not to perforate the lacrimal fascia and the periorbita, the latter being elevated by blunt dissection from before backward over the surface of the lamina papyracea.

It is worth noting that with this incision edema of the lower lid is a rare occurrence—it does not appear to occur if the infraorbital incision is not extended too far outward.

A direct approach to the ethmoid mass and neighboring sinuses is thus obtained, and it has the advantage that the surgeon is working

7. Patterson, N.: Lancet **2**:633-635 and 694-698, 1934; J. Laryng. & Otol. **54**: 235-244, 1939; External Operations on Nasal Accessory Sinuses, Arch. Otolaryng. **36**:311-326 (Sept.) 1942.

parallel to, and from below, the cribriform plate and the roof of the ethmoid cells, so that at no time is he in danger of fracturing these important structures. All his work is done under direct vision, and there is no groping in the dark in the recesses of the ethmoid labyrinth. From this approach, also, the frontal sinuses can be adequately drained, and by removing the uncinate process of the ethmoid bone, as well as the middle turbinate (and if necessary a portion of the anterior edge of the perpendicular plate of the palate bone), the maxillary sinus can be readily inspected and dealt with. This opening remains permanently, and lavage of the sinus, if subsequently necessary in the healing stage, is carried out by passing the cannula outward over the inferior turbinate. The sphenoid sinus is also within easy access for inspection and treatment. If necessary, both sides of the nose can be operated on at the one operation. A further important advantage is that the incision is so placed that the scar rapidly becomes invisible and there is no surface deformity. Occasionally there is a little diplopia lasting for a week or two, possibly owing to a disturbance of the origin of the obliquus inferior muscle, but it always passes off, as the suspensory ligament of Lockwood holds the eyeball in place even after complete excision of the maxilla. In a large number of cases (almost 100) in which Mr. Patterson and I have performed this operation we have encountered no intracranial complications, and the resulting scar in the crease of the eyelid has been negligible. In fact, it is often difficult a few months later to tell which side has been operated on.

SUMMARY AND CONCLUSIONS

A new method is put forward whereby it is possible to excise the superior maxilla in its entirety without the external incisions advocated from the inception of the operation. The result of the one operation performed (cases requiring this operation are rare in the military services) was extremely successful, and I see no reason why it should not be so in all cases in which the condition is operable; even large growths, for which I strongly recommend the use of diathermy, could be removed in this manner; if they are adherent to the skin of the cheek, perhaps this procedure must be combined with excision of that portion of the cheek involved, which could be later replaced by a tubed pedicle graft. If involvement of the ethmoid mass occurs, it might be more convenient to supplement my oral incision with Patterson's infra-orbital one. This incision may be used also for a preliminary inspection to determine the extent of the disease in the ethmoid area. According to Norman Patterson, removal of the hard palate should be carried out in every case of cancer of the maxilla, for it increases the facility of subsequent irradiation and allows more complete inspection and recognition in some cases of recurrence, which could otherwise pass unob-

served. Diathermy, which greatly facilitates the treatment of cancer of the mouth, the nose and the pharynx, was also introduced into this country by Norman Patterson [7] (1934) and subsequently was universally employed in Sweden.

Thus it will be seen that by the approach described, the upper jaw and adjacent sinuses can now be safely excised in whole or in part without fear of external mutilation or resulting deformity and that the gross defects in speech and mastication can be successfully overcome. Therefore, the operations almost abandoned on these accounts should once more resume their rightful place in the treatment of cancer and certain chronic diseases of this region.

Permission to publish the case reported was given by Surgeon Vice Admiral Sir P. T. Nichols. The obturators and the fixing appliance were constructed by Lieutenant Commander (D) Ferris R.N. and Dr. Gibson, of Glasgow Dental Hospital. Mr. Norman Patterson helped in the preparation of the article. Dr. W. W. Woods examined the specimen and made the pathologic report.

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APICAL PETROSITIS

Medical and Surgical Management in Cases With and Without Complicating Meningitis

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AND
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ATTENTION has been drawn within the past decade to the clinical syndrome of apical petrositis. The syndrome was first completely described in its various phases by Baldenweck [1] in 1908. Excellent presentations of the clinical syndrome by Eagleton,[2] Kopetzky and Almour [3] and Ramadier [4] revived interest in this condition. Many excellent reviews of the literature have been given, and no attempt will be made to repeat them here.

Three cases of apical petrositis are presented because they illustrate the solution of the problems of medical treatment and surgical management that the otologist may encounter in cases of petrositis with or without complicating meningitis. These cases stress the importance of a careful and complete history, they demonstrate the need for adequate and primary surgical treatment in instances in which symptoms of petrous involvement develop in the presence of an apparently adequately draining ear and they discourage dependence on chemotherapy alone. They show the necessity for approaching each case as an individual problem, the selection of the surgical approach not being planned prior to operation but determined at the time of operation according to the anatomicopathologic changes present.

Prior to operation, complicating meningitis should be well under control, preferably with a combination of a sulfonamide compound and penicillin. The use of a sulfonamide compound and penicillin with

From the Section on Otolaryngology and Rhinology, Mayo Clinic.

1. Baldenweck, L.: Étude anatomique et clinique sur les relations de l'oreille moyenne avec la pointe du Rochèr, le ganglion de Gasser et la vi[e] paire cranienne, Paris, G. Steinheil, 1908.

2. Eagleton, W. P.: Localized Bulbar Cisterna (Pontile) Meningitis, Facial Pain and Sixth Nerve Paralysis and Their Relation to Caries of the Petrous Apex, Arch. Surg. **20**:386-420 (March) 1930.

3. Kopetzky, S. J., and Almour, R.: The Suppuration of the Petrous Pyramid: Pathology, Symptomatology and Surgical Treatment, Ann. Otol., Rhin. & Laryng. **39**:996-1016 (Dec.) 1930; **40**:157-177 (March); 396-414 (June); 922-975 (Sept.) 1931.

4. Ramadier, J.: Les ostéite profondes du rocher (Pétrosite-rochérite). Bull. Soc. franç. d'oto-rhino-laryng. **46**:1-178, 1933.

adequate surgical treatment has greatly increased the recovery rate in cases of petrositis and its complications.

REPORT OF CASES

CASE 1.—A 12 year old boy was admitted to the hospital on March 15, 1944. He had suffered from intermittent otalgia for a period of six weeks. Nine days before admission, severe persistent otalgia developed on the left side. Myringotomy was performed the following day and drainage established, with relief of the earache. The ear continued to discharge mucopurulent material. The day after the myringotomy a dull throbbing headache developed in the left frontoparietal, supraorbital and retro-orbital regions. The pain was intermittent, lasting several hours at a time, occurring frequently at night and awakening the patient from a sound sleep. On his way to the hospital diplopia on lateral gaze to the left developed.

On admission to the hospital, the temperature was subnormal, but the pulse and the respirations were within normal limits. Examination of the ears revealed a profuse mucopurulent discharge from the left ear from an anteroinferior perforation. There was no drooping of the posterosuperior wall of the canal, nor was tenderness elicited over the mastoid process. A mucopurulent discharge was seen in both nasal passages. Moderate granular pharyngitis was noted. Diplopia was present on looking to the left, the result of paresis of the left external rectus muscle of the eye. Examination of the fundi of the eyes gave negative results. The findings of the general physical examination were otherwise negative.

The blood leukocytes numbered 12,300 per cubic millimeter of blood, with 78 per cent neutrophils, 14 per cent lymphocytes, 6 per cent monocytes and 2 per cent eosinophils. The erythrocytes totaled 4,760,000 per cubic millimeter of blood; the hemoglobin content of the blood was 13.8 Gm. per hundred cubic centimeters.

Aural cultures revealed hemolytic streptococci and Staphylococcus aureus.

Roentgenographic examinations of the thorax and the sinuses gave negative results. The roentgenograms of the mastoid processes revealed large pneumatic cells in the petrous pyramids, with apparent destruction of the carotid canal in its horizontal portion on the left side. There was cloudiness of the cells of the mastoid process on the left with evidence of involvement of the deeper perilabyrinthine cells.

The day after the patient's admission to the hospital, treatment with a sulfonamide compound was started. An initial dose of 30 grains (2 Gm.) of sulfamerazine was given, followed by a dose of 15 grains (1 Gm.) every six hours. A total of 160 grains (10 Gm.) of sodium bicarbonate was given daily in divided doses along with the sulfamerazine. A concentration of 9 to 10 mg. per hundred cubic centimeters of blood was maintained.

On March 18 complete mastoidectomy and exploration of the perilabyrinthine cells were carried out through an endaural approach. The mastoid antrum was opened with an electrically driven perforator and the aditus enlarged with a curet. The cells of the mastoid process were much broken down and filled with purulent exudate. The disease had uncovered the lateral sinus at the lower turn. The sinodural angle was exposed, and dissection was carried forward, the lateral wall of the epitympanum being removed to the malleoincudal joint. The solid angle was then removed, outlining the lateral, superior and inferior semicircular canals. No lead could be found to the apex in these areas. The cells leading into the apex below the labyrinth were then explored. A purulent tract involving the retrofacial group of cells was found leading downward. The jugular bulb was

found lying against the inferior surface of the capsule of the labyrinth, but it was possible to enter the apex between the jugular bulb and the descending portion of the internal jugular vein. A rather large tract was exenterated and finally a large cell opened which was believed to represent the apical cells shown by the roentgenograms. A small rubber catheter was placed down to the apex of the pyramid through this tract and brought through the mastoid incision.

The postoperative course was uneventful. The abducens paresis had completely disappeared by the fifth postoperative day. Administration of sulfamerazine was continued until the patient's dismissal from the hospital on March 25.

CASE 2.—A 9 year old girl entered the hospital immediately on reaching Rochester, July 16, 1944. The history of her illness dated back to March 1944, at which time she had measles. Following this, she complained sporadically of otalgia on the left side. On May 1 the pain became more persistent and more severe, and on May 9 the left ear drum ruptured spontaneously, followed by profuse otorrhea. On May 19 the patient was seen by her local physician. At this time her temperature was 102 F., and severe pain was present in the left side of the head and about the left ear. The patient was hospitalized, and sulfadiazine was administered but was discontinued one and a half days later because of nausea. Penicillin was then administered intramuscularly, but the symptoms continued. Roentgenograms revealed marked clouding of all the cells of the left mastoid process.

On May 23 complete mastoidectomy was performed; Staph. aureus was isolated from the cells of the involved mastoid process. The immediate postoperative recovery was essentially uneventful except for some dizziness on quick movements of the head. From May 28 to June 14 vomiting was noted approximately once daily and there was persistent left temporal headache.

An audiogram taken on June 14 revealed normal hearing.

On June 24 the patient was again hospitalized by her local physician because of pain over the left temple and low grade fever. Penicillin again was administered. On June 26 paresis of the left side of the face developed and lasted for several days. The temperature subsided, and on July 1 the patient was dismissed from the hospital. Fever, temporal pain and dizziness persisted and gradually increased up to the time when we first saw the patient on July 16.

The examinations carried out at this time were greatly hampered because of the behavior of the child. There was questionable tenderness over the left mastoid process; the left tympanic membrane was intact and slightly dull. There was no evidence of facial paralysis. The temperature on admission was 100 F., the pulse rate 128 and the respiratory rate 22. The concentration of hemoglobin was 12.5 Gm. in 100 cc. of blood; the erythrocytes numbered 4,350,000, and the leukocytes 14,600, per cubic millimeter of blood, with 31 per cent lymphocytes, 7 per cent monocytes, 60 per cent neutrophils, 1 per cent eosinophils and 1 per cent basophils. Blood cultures were negative. There was questionable stiffness of the neck; the stiffness was more apparent the next morning, at which time neurologic examination showed a mild positive Kernig sign, mild opisthotonos and a moderate degree of rotary nystagmus to the right. The ocular fundi revealed chronic choking of the disks of 1 diopter. The slightly turbid cerebrospinal fluid contained 500 polymorphonuclear leukocytes and 30 lymphocytes in each cubic millimeter of spinal fluid, with total protein 260 mg. per hundred cubic centimeters of spinal fluid and globulin grade 2+ (on a basis of 1 to 4, in which 1 represents the least and 4 the greatest amount of globulin). Bacteriologic examination revealed no growth of organisms. Roentgen examination of the mastoid processes revealed post-operative changes on the left, with cloudiness of the left petrous pyramid and

evidence of destruction in the left petrous apex. Since these changes were thought sufficient to explain the persistent fever, the transient facial palsy and the signs of meningeal irritation, exploration of the left mastoid process and petrous pyramid was advised.

Prior to operation penicillin was administered. At the time of the lumbar puncture 10,000 units in 10 cc. of isotonic solution of sodium chloride was instilled intrathecally. The next day 40,000 units was given intravenously, and from then on 80,000 units was given intramuscularly, 10,000 units every three hours.

On July 18 an exploratory operation was performed. The postauricular incision was opened, and it was found that the mastoid process had been completely exenterated except for the tip and the perilabyrinthine and retrofacial group of cells, which contained pus. It was possible to reach the petrous apex through a preformed cell tract extending above the jugular bulb and below the labyrinth and by another preformed cell tract extending to the apex through the arch of the anterior vertical canal. In the latter region a large opening was made into a cavity containing pus and infected granulation tissue in the petrous tip. One rubber tube was placed into the antrum for drainage. The postauricular incision was closed with Zytor and silk. Myringotomy was then performed and the canal packed to prevent atresia. Immediately after operation a transfusion of 500 cc. of blood was given.

The postoperative course was uneventful. Intramuscular administration of penicillin was continued, and on July 19, 30 grains (2 Gm.) of sulfadiazine was administered, followed by 15 grains (1 Gm.) every four hours. Forty grains (2.6 Gm.) of sodium bicarbonate was given with the sulfadiazine to maintain alkalinity of urine, and an attempt was made to keep the fluid intake greater than 2,500 cc. per day. The concentration of sulfadiazine ranged from 10 to 13 mg. per hundred cubic centimeters of blood. The temperature ranged from 100 to 102 F. and on July 22 approached normal.

Administration of both penicillin and sulfadiazine was continued up to the time the patient was dismissed from the hospital on July 29.

On August 13 the patient returned to Rochester because of recurrence of fever. Examination on admission gave essentially negative results. She was hospitalized for observation, and on the fifth day, August 18, nausea and vomiting, headache and fever with temperature rising to 103 F. developed. Nuchal rigidity was present.

Administration of penicillin and sulfadiazine in combination with sodium bicarbonate was begun immediately. An initial dose of 30 grains (2 Gm.) of sulfadiazine was given, followed by 15 grains (1 Gm.) every four hours and accompanied by 30 grains (2 Gm.) of sodium bicarbonate. The blood sulfadiazine level was maintained between 10 and 13 mg. per hundred cubic centimeters. Penicillin was administered intramuscularly, 10,000 Oxford units every three hours. Lumbar puncture revealed cloudy, turbid cerebrospinal fluid under a pressure of 450 mm. of water. Polymorphonuclear leukocytes were too numerous to count, with only a few lymphocytes. No organisms were noted on smear or culture. The daily intrathecal instillation of 10,000 units of penicillin was carried out for four days, from August 18 to August 21, at which time the meningitis was well under control, the polymorphonuclear leukocytes numbering 152 cells and the lymphocytes 55 in each cubic millimeter of cerebrospinal fluid.

On August 22 a Ramadier-Lempert type of apicectomy was carried out. The postauricular incision was reopened, and dense fibrous tissue was found closing the posterior tracts to the pyramid. When the granulation tissue was removed, necrotic tissue and pus were found in the tracts. A radical operation was performed and the drum and ossicles were removed. The facial canal was lowered, the carotid

artery was uncovered and the apex was entered by following the carotid artery. A blood transfusion of 500 cc. was administered during operation. The postoperative recovery was uneventful. Administration of penicillin and sulfadiazine was continued up to the patient's dismissal from the hospital on September 2. The patient has been symptom free since dismissal (five months), and the cavity left by the radical operation has become epithelized and dry.

CASE 3.—A 39 year old man entered the hospital directly on the evening of Dec. 2, 1944. He presented a history of tinnitus and mild otalgia on the right side with general malaise of five weeks' duration. At the time of the onset he went to bed because of slight chills and fever, which were accompanied by nausea and vomiting. His temperature remained around 101 F. Spontaneous otorrhea developed on the right side and continued for three days. Stiffness of the neck and severe occipital headache developed, gradually increasing in severity over the three day period, at which time pain developed over both eyes, and the right eyeball, it was stated, protruded.

One week after the onset of otorrhea, while the proptosis of the eyeball was noticeable, complete paralysis of the right upper and lower extremities developed. This remained for three weeks, gradually improving as the stiffness of the neck and headache receded.

Two weeks before being admitted to the hospital the patient was up and around and was able to carry on with the chores on his farm. During this time he felt well except for an occasional slight elevation of temperature and brief episodes of suboccipital pain.

Three days before our examination was carried out, the right eye again started to protrude, and the severe suboccipital pain was again noted. This lasted for two days.

The night before admission to the hospital, sudden protrusion of the right eyeball was again stated to have occurred, accompanied by the headache. All symptoms subsided within a few hours.

The patient's past history revealed intermittent otorrhea on the right side for the past twenty years, especially in the winter months. He stated that he thought this may have originally been started by a traumatic perforation of the right ear drum with a piece of straw.

Examination of the ears revealed some maceration of the right external auditory canal. The right tympanic membrane was bulging markedly in the posterosuperior aspect. No perforation was noted. There was no sagging of the posterior wall of the canal. No tenderness was elicited in the region of the mastoid process. Marked conduction deafness was present, the patient being able to hear only shouted words. The left ear was normal. Examination of the nose revealed marked septal deflection to the left. There was no evidence of active sinusitis. The tonsils were enlarged and appeared chronically infected. A trace of mucopus was noted in the nasopharynx. There was no rigidity of the neck. Slight horizontal nystagmus to the left and diplopia on extreme lateral gaze to the left were noted.

The temperature was 98.6 F.; the pulse rate 60, and the respiratory rate 20. The blood revealed 13.1 Gm. of hemoglobin per hundred cubic centimeters and 5,030,000 erythrocytes and 25,200 leukocytes per cubic millimeter, with 80 per cent neutrophils, 13 per cent lymphocytes and 7 per cent monocytes. Urinalysis gave essentially negative results except for albumin grade 1.

Roentgenograms of the mastoid processes revealed diffuse cloudiness of the right mastoid process with cellular destruction and involvement of the petrous tip.

Administration of sulfadiazine was begun, 15 grains (1 Gm.) every four hours, in combination with sodium bicarbonate.

Four hours after the patient's admission to the hospital his temperature rose to 102 F. Moderate rigidity of the neck was noted. Right myringotomy was performed, with release of mucoid material. Intravenous administration of penicillin was started (40,000 Oxford units every twenty-four hours) in combination with that of sulfadiazine. Material from the right ear when cultured revealed micrococci. Blood culture revealed micrococci, which undoubtedly represented a contamination. The temperature rose to 104 F.

A neurologic examination revealed a marked increase of meningitic symptoms. Lumbar puncture was performed and cloudy opalescent cerebrospinal fluid obtained under a pressure of 49 cm. of water. The fluid revealed polymorphonuclear leukocytes too numerous to count. The total protein amounted to 180 mg., the sugar to 9 mg. and the chlorides to 648 mg. per hundred cubic centimeters of spinal fluid. Culture of the spinal fluid on blood agar revealed type V Diplococcus pneumoniae. Following removal of 10 cc. of cerebrospinal fluid, 10 cc. of penicillin (10,000 Oxford units) was injected intrathecally.

On December 4, the patient appeared to be somewhat clearer mentally, and there was some decrease of temperature. Lumbar puncture was again carried out, 10 cc. of spinal fluid was removed, and 10,000 units of penicillin was injected intrathecally. This was carried out daily up to December 7. The patient's condition gradually improved, and the temperature reached normal on December 5. The oral administration of sulfadiazine and the intravenous administration of penicillin were continued.

On December 9, a combined complete exenteration of the cells of the mastoid process and radical mastoidectomy with exenteration of the petrous apex (Ramadier-Lempert technic) was carried out on the right side. The mastoid cortex was thickened and sclerotic. The cells in the periantral region and the periapical groove were filled with thick mucopus. Following complete exenteration of the cells, a radical operation was done. On taking down the bridge, the area around the fenestra ovalis was found covered with granulation tissue, after removal of which granulation tissue seemed to come from the oval window. Labyrinthectomy was accordingly done, and all three canals and the cochlea were found filled with infected granulation tissue. Dura over the cerebellum and the temporosphenoidal lobe was uncovered and found to be normal. The postauricular incision was then extended after the manner of Eagleton, and exenteration of the petrous apex was performed by uncovering and following the carotid artery. In the apex an area 2 by 1 cm. was located which contained soft, red, easily bleeding bone, apparently an area of osteomyelitis. This was completely exenterated. The incision was dusted with sulfanilamide powder, and a Koerner type of plastic repair was fashioned on the external canal. A rubber tube was placed in the external canal to maintain drainage and prevent atresia. The postauricular incision was closed with Zytor and silk.

Within twenty-four hours after operation weakness of the right side of the face gradually developed, but this showed a tendency toward recovery within the next five days.

On December 13, the administration of penicillin was discontinued, and the dose of sulfadiazine was halved. On December 17 the patient was dismissed from the hospital with the wound in good condition. He had almost completely recovered from the facial palsy.

COMMENT

In the 3 cases of petrositis presented, 1 with paralysis of the abducens nerve and 2 with complicating meningitis, certain facts become evident which are applicable to most cases of petrositis.

Prior to operation on the petrous pyramid the preparation of the patient should be such as to place him in the best possible physical condition. It is advisable that the treatment of complicating meningitis should be well under way, preferably with a combination of a sulfonamide drug and penicillin. The sulfonamide compound which we have found to be clinically superior at the present time is sulfadiazine.[5] When this is used alone in cases of meningitis, it is advisable to maintain a blood level of 18 to 20 mg. per hundred cubic centimeters; this has been found to be adequate. In cases of petrositis without complicating meningitis, when sulfadiazine is used alone, blood levels of 10 to 12 mg. per hundred cubic centimeters are advisable. Sulfamerazine may be found in the future to be equally favorable because of its greater solubility, its ability to reach higher concentrations in the blood, the maintenance of more constant blood levels through its slower excretion and because of its lower toxicity. However, from our experience with this drug at the present time we feel that it is clinically less effective than sulfadiazine. The blood levels maintained should be the same as those of sulfadiazine.

When large doses of sulfadiazine are being used, it is important that adequate intake and output of fluids be maintained. The intake should be 3,000 cc. per day, and the urinary output should be 1,500 cc. or more. If the fluid intake is too low, precipitation of the sulfonamide crystals in the renal tubules, pelvis or ureter may occur, and oliguria or complete anuria may result. If the fluid intake is too high, there will be a lowering of the concentration of the sulfonamide compound in the blood as a result of excretion; also acute intracranial hypertension may be precipitated. Even though the fluid intake may be adequate, renal complications may occur if the dose of sulfadiazine is high. This may be prevented to a large degree by adequate alkalinization. The importance of alkalinization of the urine has been stressed by Gilligan and his collaborators.[6] They have shown that renal complications are markedly reduced when the urine is kept alkaline. They have demonstrated that sulfadiazine is twenty times and acetylsulfadiazine thirty times more soluble at p_H 7.5 than at p_H 5.0. They advise an initial dose of 6 Gm. (90 grains) of sodium bicarbonate followed by 2.6 Gm. (40 grains)

5. Brown, A. E.: Sulfonamide Treatment of Acute Bacterial Meningitis, Kentucky M. J. **42**:75-80 (March) 1944.

6. Gilligan, D. R.; Garb, S.; Wheeler, C., and Plummer, N.: Adjuvant Alkali Therapy in the Prevention of Renal Complications from Sulfadiazine, J. A. M. A. **122**:1160-1165 (Aug. 21) 1943.

every four hours. If necessary to give larger amounts of sulfadiazine, they suggested increasing the dose of sodium bicarbonate. They suggested continuing the alkali therapy for twenty-four hours after the discontinuance of the administration of sulfadiazine. They cited Loughlin and collaborators, who have shown that when large doses of sodium bicarbonate are given initially with the sulfadiazine the blood level rises twice as fast as when the sulfadiazine is given alone.

The combination of a sulfonamide compound and penicillin produces a synergistic effect.[7] In cases of meningitis penicillin should be administered intrathecally as well as intravenously (or intramuscularly) because of the fact that this drug does not pass freely to the spinal fluid from the blood stream. It has been demonstrated [8] that an effective local concentration of penicillin can be maintained for twenty-four hours without undue toxic reactions. It has been noted that there is a more rapid absorption from the cerebrospinal fluid in patients with meningitis than in normal persons. After the meningitis has been brought under control, it then is necessary to eradicate the disease in the petrous pyramid surgically, because unless this is done the infected focus may lie dormant, protected by a layer of necrotic material and pus, to become reactivated after the withdrawal of chemotherapy. No more important lesson can be taught than the inadequacy of chemotherapy alone to clear up foci in the petrous pyramid, especially when meningitis is imminent or has been present. Apical petrositis with its high incidence of intracranial complications is not a condition with which it is safe to temporize, although such a course may occasionally be followed successfully in cases of uncomplicated mastoiditis if the patient is under careful observation.

When possible, drainage of suppurative foci in the petrous pyramid should be accomplished by following preformed cell tracts to the involved region. As pointed out by one of us [9] in a previous paper, when a cellular pyramid is present, increased room in and around the region of the labyrinthine capsule is usually present. If adequate drainage can be secured by following the perilabyrinthine cell tracts, well described by Ramadier,[4] the necessity of destroying the hearing can be avoided. We feel, therefore, that drainage for apical petrositis should be done in stages, the perilabyrinthine regions being first explored and the more destructive procedure of complete apicectomy being reserved for a later

7. Ungar, J.: Synergistic Effect of Para-Aminobenzoic Acid and Sulphapyridine on Penicillin, Nature, London **152**:245-246 (Aug. 28) 1943. Herrell, W.: Personal communication to the authors.

8. Rammelkamp, C. H., and Keefer, C. S.: The Absorption, Excretion and Toxicity of Penicillin Administered by Intrathecal Injection, Am. J. M. Sc. **205**: 342-350 (March) 1943.

9. Williams, H. L.: Primary Operation for Suppuration of the Petrous Pyramid: Report of Two Cases, Minnesota Med. **19**:367-372 (June) 1936.

date when it may be found necessary.[10] If closed apicitis is present and preformed tracts have not been found on careful and extensive exploration of the perilabyrinthine regions, complete apicectomy by the Ramadier-Lempert technic is indicated without further delay. If history and examination definitely indicate a suppurative region in the pyramid medial to the capsule of the labyrinth, adequate drainage must be secured.[11]

To perform complete mastoidectomy alone and then observe the patient for a period is a policy that should be pursued only when there is a reasonable doubt that the symptoms produced represent apicitis. As has been pointed out by one of us (Williams [12]), disease sealed off in the cells along the sinodural angle is capable of producing a Gradenigo syndrome, and such infected cells may have been overlooked. This should rarely happen, however, if an adequate exploration of the cells of the mastoid process has been done. If meningitis is present and no adequate explanation for its presence is presented during the course of complete mastoidectomy, the dura should be uncovered both over the temporosphenoidal lobe and over the sinus and the cerebellum. If still no explanation of intracranial extension of the disease is found, apicectomy should be seriously considered, because of the frequency with which apicitis has been found to be the underlying cause of such extension. The association of chronic sphenoiditis with apicitis, as pointed out by Eagleton,[13] should be borne in mind.

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10. Lillie, H. I., and Williams, H. L.: Suppuration of the Petrous Pyramid: Report of Two Cases, Arch. Otolaryng. **15**:692-696 (May) 1932.

11. Williams, H. L.; Herrell, W. E.; Brown, A. E.; Kernohan, J. W., and Wagener, H. P.: Otitic Meningitis: A Review of the Literature and Report of Results Five Years Before and Since the Introduction of Chemotherapy, Laryngoscope **52**:835-869 (Nov.) 1942.

12. Williams, H. L.: Mastoiditis with Unusual Symptoms, S. Clin. North America **15**:1265-1269 (Oct.) 1935; footnote 9.

13. Eagleton, W. P.: Meningitis: The Result of Disease of the Petrous Apex and Sphenoidal Basis, Surg., Gynec. & Obst. **60**:586-587 (Feb. 15) 1935.

EFFECT OF EMOTIONS ON THE HYDROGEN ION CONCENTRATION OF NASAL SECRETION IN SITU

With a Comment on the Terminology of Nasal Hydrogen Ion Concentration Measurement

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THAT there is a relationship between emotional factors, the frequency of acute colds and their sequelae and altered nasal function has been recognized, although not yet completely defined, by a number of investigators. It is known that the abnormal, alkaline nasal secretion associated with infection of the upper respiratory tract often excoriates tissue when descending on the skin of the upper lip. If the patient with acute rhinitis remains relatively removed from the routine decisions and frustrations of his working day during the acute phase, when the nasal membranes are engorged and sensitive, with secretion flowing excessively, the nose becomes less painful and the secretion diminishes; so MacAuliffe, Goodell and Wolff [1] observed in their experimental studies on headache and pain from nasal and paranasal structures.

Congestion of the nasal mucous membrane, they noted, may occur as an accompaniment of anxiety or resentment. In this connection, the coupling of the effects of such emotions with those from nasal infection may aggravate congestion and precipitate pains of nose and head. Headache associated with disease of the nasal and paranasal structures is intensified by emotional states like anxiety and resentment, and these serve to increase the engorgement of the mucous membranes. If to the presence of disease of the nasal and paranasal cavities is added a disturbing life situation with conflicting emotions, there may follow a summation of effects precipitating a severe headache at a time when the evidence of nasal disease is little different from that of the headache-free period.

Local vasomotor changes in the erectile tissues of the nose—as accompaniments of stress, exhaustion, anxiety and fear—have been described by Fenton.[2] He declared that "the otolaryngologist has reason

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1. MacAuliffe, G. W.; Goodell, H., and Wolff, H. J.: Experimental Studies on Headache: Pain from the Nasal and Paranasal Structures, A. Research Nerv. & Ment. Dis., Proc. **23**:185, 1943.

2. Fenton, R. A.: Some Observations on Nasal Neurology, Ann. Otol., Rhin. & Laryng. **50**:492 (June) 1941.

occasionally to note the vasomotor effects of fear before the use of any instrument or drug." Following severe shock and pain elsewhere in the body, the turbinates become relatively bloodless. "Contrast with these appearances the congestion and turgidity of anger, of excitement, of heavy eating or drinking. Cases of extreme nasal stuffiness due to sexual stimulation are not infrequently reported by gynecologists, urologists and psychoanalysts. The role of emotion in the vasomotor control of the nose may thus be very considerable."

It is Cone's [3] opinion that emotional states—fear, apprehension and anxieties—play an important part in the causation of sinus disease in children. Recently Despert [4] made a survey of the records of 63 children admitted to the Payne Whitney Nursery School from 1937 to 1942 to determine whether a relation could be observed between common colds and emotional states. Among children with the highest ratio of absences due to colds were 8 from broken homes, a large number of children with emotional stresses due to causes other than disruption of the home, and a few apparently free from stress. In the case of children from broken homes, all with high incidence of colds, there was evidence of gross emotional disturbances of the nature of anxiety and frustration.

As to the psychosomatic literature, Saul [5] reported that in a series of 15 patients with frequent colds whom he treated for various neurotic symptoms colds were markedly reduced or did not occur following treatment. In 9 of these persons it was possible to note that the colds "occurred in situations of frustration of strong, mostly unconscious, receptive demands with more or less repressed rage."

EMOTIONS AND NASAL p_H

In the second of my communications [6] on the significance of the p_H of nasal secretion in situ I called attention to the fact that nasal p_H varies with sleep and rest, diurnally and nocturnally, and with the ingestion of food, and that it can be changed not only by infection but by alteration of mood. These changes of hydrogen ion concentration are by no means isolated phenomena, taking place only in secretion lying on the nasal mucous membrane. Grossman and Brickman,[7] for example,

3. Cone, A. J.: Sinus Disease in Children, Tr. Am. Acad. Ophth. **46**:79 (Nov.-Dec.) 1941.

4. Despert, J. L.: Emotional Factors in Some Young Children's Colds. M. Clin. North America **28**:603 (May) 1944.

5. Saul, L. J.: Psychogenic Factors in the Etiology of the Common Cold and Related Symptoms, Internat. J. Psycho-Analysis **19**:451 (Oct.) 1938.

6. Fabricant, N. D.: Further Studies: Significance of the p_H of Nasal Secretions in Situ, Arch. Otolaryng. **34**:297 (Aug.) 1941.

7. Grossman, L. I., and Brickman, B. M.: Some Observations on the p_H of Saliva, J. Dent. Research **16**:409 (Oct.) 1937.

have demonstrated that the hydrogen ion level of saliva varies not only in health but, significantly, in disease and that, like nasal secretion, saliva shows the nocturnal p_H lower than the diurnal p_H. Variations in salivary p_H also occur after the ingestion of food. (The urine passed a short time after rising in the morning is less acid than that formed during sleep,[8] and this change in urinary reaction is spoken of as the "morning alkaline tide.") Further, Starr [9] found that emotional excitement changes the p_H of saliva.

As so often happens, it was by sheer accident that during the first two years of my investigations of nasal p_H I became cognizant of a relationship between emotions and nasal p_H. Among my early subjects was a young woman whom I studied daily; later I learned, she was under treatment for a minor psychiatric ailment. As a subject with normal nasal p_H she appeared willing, calm and cooperative. On one occasion, however, she became perturbed emotionally with striking suddenness.

In order to explain her distraught behavior, she requested that the glass electrode be removed from its in situ position in the nasal cavity. Immediately prior to this the nasal p_H had been found normal, the secretion being slightly acid (p_H 6.39 to 6.50). On confessing that she was convinced she would never completely recover from her ailment, her distress, magnified by this time through excited conversation, grew by leaps and bounds. After I had repeatedly reassured her that she had misinterpreted the comments of her physician, I reintroduced the glass electrode for additional nasal p_H measurements. Thereafter for approximately twenty minutes the nasal secretion was consistently alkaline (p_H 7.15 to 7.33); it then returned to the original, slightly acid state. On another occasion I deliberately introduced her ailment as a subject of conversation, advising her to refrain from any comment no matter how perturbed she might feel inwardly. The normal, slightly acid nasal secretion was once again converted to an abnormal, alkaline secretion—this time for twelve minutes—before the p_H descended to the original level. Here, all possible precautions were taken to eliminate movements of the patient's head consequent to emotional disturbance.

The effect of sudden noise on the nasal secretion of an unsuspecting subject was first demonstrated to me when one of my technicians unintentionally dropped a massive iron basin on the stone floor of the laboratory. The subject's nasal p_H bounded into the range indicating an alkaline reaction, stayed at that level for six minutes, then descended to the level indicating a normal, slightly acid state. I questioned the accuracy of these p_H readings because the subject on becoming startled

8. Leathes, J. B., cited by Best, C. H., and Taylor, N. B.: The Physiologic Basis of Medical Practice, Baltimore, Williams & Wilkins Company, 1943, p. 656.

9. Starr, H. E.: Studies of Human Mixed Saliva, J. Biol. Chem. **54**:43 (Sept.) 1922.

moved the glass electrode inadvertently. Several days later, without the subject's knowing that a loud noise impended and with precautions taken to remove the glass electrode, the incident was repeated and similar findings were noted: The normal, slightly acid nasal secretion became alkaline for five minutes and then returned to the original state. In a third subject, some weeks later, a similar conversion of the nasal secretion from a normal, slightly acid level to an abnormal alkaline state lasted four minutes. The time necessary for reestablishing composure in both subjects was of short duration.

As in the case of vasomotor changes occurring in the nasal mucous membrane as the result of various emotional states, it appears that it is only in susceptible persons that emotional changes can produce transient conversions of nasal secretion from a normal, slightly acid to an abnormal alkaline state. Although my own findings on the effect of emotional changes on nasal secretion have not been experimentally extensive, it is reasonable to assume that these variations, like vasomotor changes, will not take place within the confines of every nose. It is only in susceptible human noses that there will be demonstrable responses to anxiety, fear, worry and fright.

TERMINOLOGY OF NASAL p_H MEASUREMENT

In the normal nose the p_H of nasal secretion in situ as determined by means of the glass electrode is a measurement of the hydrogen ion concentration of the mucous blanket in intimate union with the underlying epithelium. In the abnormal nose it is a measurement of the hydrogen ion concentration of the secretion lying on the mucous membrane. The accepted meaning of the term "in situ" implies—"in its original site or position." These interpretations are, I believe, inherent in my published papers and have been so understood by the preponderant majority of rhinologists interested in the subject. To interpret measurements of the hydrogen ion concentration of nasal secretions in situ otherwise is to engage in what is one of the commonest faults of criticism, namely, the refusal to consider what it is that an investigator communicates.

In the normal nose it is possible for the most part to measure only the hydrogen ion concentration of the mucous blanket as this lies in its original site or position on the epithelium. The glass electrode when inserted into the normal nose obviously and of necessity first comes into contact with the overlying mucous blanket, since it is this vital and dynamic secretion that presents itself most superficially to the electrode. Likewise, in the abnormal nose the glass electrode first comes into contact with abnormal secretion covering an abnormal mucous membrane. There may be unusual circumstances in which mucous blanket and nasal secretion are entirely absent but these instances are uncommon.

Individual measurements of the hydrogen ion concentration of nasal secretion in situ and of that of the underlying mucous membrane are, of course, impossible by present day technics. On previous occasions I have directed attention to such difficulties. In my first communication [10] reference was made to "fundamental changes in p_H of the secretions on the nasal and buccal mucosa"; and in the work on the p_H of the throat [11] I stated at some length that it is the total collection of the various secretions imposed on the throat membrane which influences such measurements.

So far as it concerns the p_H values of local medicaments, investigators of in situ p_H measurements of secretions in union with the skin, the conjunctival sac, the vagina and the rectum have for some years drawn valid therapeutic conclusions directly from their measurements of the various secretions found in their original positions on underlying mucous membrane and tissue surfaces. In keeping with these acknowledged and accepted experiences in other clinical fields, I have advanced similar premises with regard to nasal medication. Contrary to the surprising position taken by Parkinson,[12] it is my contention that the treatment of the interior of the nasal cavity by means of rational, physiologic nasal medicaments requires not only treatment of mucous membrane surfaces (including ciliary action) but treatment of nasal secretions (including the mucous blanket) as well.

Because there has been considerable investigation of the hydrogen ion concentration of the skin, a brief comment may prove of interest. In the living skin, the hydrogen ion concentration is dependent on the oil in the skin, the condition of the underlying tissue and the amount of perspiration. Investigators determining the p_H of skin have found the skin to be enveloped by an "acid mantle." Because of its acidity, the surface of the skin exhibits a pronounced defense against bacterial invasion. Speaking of therapeutics, Wise and Sulzberger [13] declared: "The logical conclusion in managing many skin diseases is, therefore, not (as so popularly and inanely reiterated) to 'alkalinize' but rather to acidify—at least, as regards the skin's surface." This sane view extends equally into the interior of the human nose.

As in the case of the normal "acid mantle" which is the physiologic and desirable covering of the skin, considered essential to its health,

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10. Fabricant, N. D.: Significance of the p_H of Nasal Secretions in Situ, Arch. Otolaryng. **34**:150 (July) 1941.

11. Fabricant, N. D.: Introduction to the p_H of the Throat, Arch. Otolaryng. **37**:169 (Feb.) 1943.

12. Parkinson, S. N.: Determinations of Intranasal p_H, Arch. Otolaryng. **41**: 68 (Jan.) 1945.

13. Wise, F., and Sulzberger, M. B.: Year Book of Dermatology and Syphilology, Chicago, The Year Book Publishers, Inc., 1938, p. 553.

normal nasal secretion (including the mucous blanket) possesses a purposeful acid barrier against infection. Viewed physiologically, the mucous blanket is far from being nonliving; in essence, it is a living structure, vital, dynamic and—as is well known—in continuous motion. Offering a highly efficient barrier to the entrance of bacteria, the acid mucous blanket is one of the truly significant living defenses of the interior of the nose.

The relationship of the hydrogen ion concentration of nasal secretion to cellular reactions has been established by Tweedie [14] and Buhrmester,[15] who found that patients with p_H 6.5 or below always had negative cultures. Tweedie made the observation that with elevation of p_H to the "alkaline side," bacteria were usually found. Their acknowledgment that acidity as reflected in low p_H is unfavorable to the growth of pathogenic bacteria furnishes corroborative evidence for the concept that nasal secretion in situ possesses a purposeful acid barrier against infection.

The work of Hansel,[16] furthermore, demonstrates that in allergy when the p_H of nasal and sinal secretions falls low on the "acid side" there is a complete disappearance of the eosinophils, and when the p_H returns to the "alkaline side" there is a return of the eosinophils. His investigation furnishes additional evidence that in recession from allergic attacks nasal secretion possesses a purposeful acid composition. Finally, the action of lysozyme, established to be optimal at a p_H on the "acid side," may perhaps explain why lysozyme is most active in the slightly acid nasal secretion of the clinically normal nose and why its action is sharply diminished in the alkaline nasal secretion accompanying the acute common cold.

SUMMARY

Attention has been directed by a number of investigators to a relationship between emotional factors, the frequency of acute colds and their sequelae and altered nasal function. Just as emotional changes can cause vasomotor changes in the nasal mucous membrane, so they can produce transient conversions of nasal secretion from a normal, slightly acid to an abnormal, alkaline state. These variations, like vasomotor changes, will not take place within the confines of every nose. It is only in susceptible human noses that there will be demonstrable responses to anxiety, fear, worry and fright.

14. Tweedie, A. R.: Reaction of Nasal Mucus, Acta oto-laryng. **24**:151, 1936.

15. Buhrmester, C. C.: A Study of the Hydrogen Ion Concentration, Nitrogen Content and Viscosity of Nasal Secretions, Ann. Otol., Rhin. & Laryng. **42**:1041 (Dec.) 1933.

16. Hansel, F. K.: Cytologic Observations on the Secretions of the Nose and Paranasal Sinuses in Allergy, Tr. Am. Laryng. A. **62**:293, 1940.

So far as concerns the p_H values of local medicaments, valid therapeutic conclusions have been drawn in a variety of clinical fields from measurements of the hydrogen ion levels of various secretions found in their original positions on underlying mucous membrane and tissue surfaces. Similar acknowledged and accepted premises have been advanced with regard to nasal medication. Intranasal treatment by means of rational, physiologic nasal medication requires not only treatment of mucous membrane surfaces (including ciliary action) but treatment of nasal secretion (including the mucous blanket) as well.

Normal nasal secretion (including the mucous blanket) possesses a purposeful acid barrier against infection. It has been established that acidity as reflected in low p_H values is unfavorable to the growth of pathogenic bacteria and that nasal secretion possesses an acid composition when receding after allergic attacks. The two phenomena point in corroboration to the significance of normal, slightly acid nasal secretion in situ.

NOTE.—Since this article was written corroborative evidence pointing to the importance of slightly acid nasal medicaments with a p_H value within the physiologic range of the nasal p_H of man has been presented by Callomon.[17] In a study of tissue changes produced in the nasal mucous membranes of normal mice by prolonged administration of various alkaline and acid solutions of sulfonamide compounds it was demonstrated that a preparation with a p_H value near the normal, slightly acid physiologic range of nasal secretion in man showed the least irritating effect.

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17. Callomon, F. T.: Tissue Changes Produced in Nasal Mucous Membrane of Normal Mice by Prolonged Local Administration of Some Solutions Containing Sulfonamide Compounds, Arch. Otolaryng. **43**:31 (Jan.) 1946.

HEALING OF FISTULAS OF THE HUMAN LABYRINTH

Histopathologic Studies

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THE most vexing problem of the operative treatment of otosclerosis is the fact that in many instances the operative fistula still heals with bony closure in spite of all improvements of the surgical technic. In attempts to solve the problem animals have been widely used, but it seems doubtful that a complete answer will ever be furnished by animal experiments alone. Otosclerosis is a disease which occurs exclusively in man and has never been observed in animals. This seems to indicate that there are basic differences between the human capsule and that of animals.

Under these circumstances the study and the analysis of the changes which take place during the healing of human fistulas have gained particular importance.

Fistula in the osseous wall of a semicircular canal either follows disease of the middle ear or is the result of operative trauma.

The lateral semicircular canal, being more accessible from the middle ear and the antrum, is also more exposed to disease and traumatism than the others.

Most frequently fistula follows chronic otitis media with cholesteatoma, sometimes chronic otitis without cholesteatoma or subacute otitis media due to Pneumococcus type III, rarely acute otitis media and occasionaly tympanomastoidectomy. Cases of tuberculosis of the middle ear will not be discussed.

Operative injury occurs most frequently in cases in which during tympanomastoidectomy the bone in the upper part of the facial ridge is taken down too far.

In the overwhelming majority of instances a fistula which is not followed by a severe labyrinthine complication heals with bony closure of the defect. Occasionally, however, the defect in the osseous wall is filled with connective tissue only, and the fistular test remains positive for an indefinite period. This is an unwelcome event in the course of suppuration of the middle ear or after operation. The condition has been discussed in the literature frequently. The main

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interest of the authors had always been toward finding ways and means of promoting a bony closure of the defect.

Contrary to the aims of previous authors, our own at the present time concern much more the factors which prevent than those which promote bony closure.

A review of the literature shows that altogether 19 anatomically examined cases are suitable for such a study (Zeroni;[1] Hegener;[2] Wagener[3] [1909, 1910]; Habermann;[4] Brock[5] [1912], 2 cases; Zange[6] [1919], 2 cases; Brock[7] [1921]; Preuss,[8] 4 cases; Mayer and Beyer;[9] Brunner;[10] Mayer;[11] Nager and Engstrom,[12] Lempert[13] [1941]). Unfortunately, many of these cases are mentioned only briefly. The frequently cited cases of Schmiegelow,[14] Zumbroich[15] and Zange[6] (1927)

1. Zeroni, O.: Beitrag zur Pathologie des inneren Ohres, Arch. f. Ohrenh. **63**:174, 1903.

2. Hegener, J.: Labyrinthitis und Hirnabszess, Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres **2**:359, 1909.

3. Wagener, (*a*) in discussion on Oertel: Cholesteatom mit Durchbruch nach dem Munde, Monatschr. f. Ohrenh. **44**:55, 1910; (*b*) in discussion on Scheibe: "Fistelsymptom," postoperative Labyrinthitis und ihre Verhütung, Verhandl. d. deutsch. otol. Gesellsch., 1910, p. 275.

4. Habermann, in discussion on Scheibe: "Fistelsymptom," postoperative Labyrinthitis und ihre Verhütung, Verhandl. d. deutsch. oto. Gesellsch., 1910, p. 274.

5. Brock, W.: Klinische und pathologisch anatomische Untersuchungen über die Frage der Labyrintheiterung, Ztschr. f. Ohrenh. **66**:267, 1912.

6. Zange, J.: Pathologische Anatomie und Physiologie der mittelohrentspringenden Labyrinthentzündungen, Wiesbaden, J. F. Bergmann, 1919; Die konservative und chirurgische Behandlung der entzündlichen Erkrankungen des inneren Ohres mit besonderer Berücksichtigung der Indikationsstellung, Ztschr. f. Hals-, Nasen- u. Ohrenh. **18**:1, 1927.

7. Brock, W.: Ein Fall von geheilter Labyrinthusur mit scheinbar zirkumskripter Labyrinthitis, Verhandl. d. Gesellsch. deutsch. Hals-, Nasen- u. Ohrenärzte, 1921, p. 412.

8. Preuss, E.: Geheilte Bogengangsdefekte, Ztschr. f. Hals-, Nasen- u. Ohrenh. **4**:352, 1922-1923.

9. Mayer, O., and Beyer, H.: 40 Jahre Radikaloperation, Ztschr. f. Hals-, Nasen- u. Ohrenh. **24**:1, 1929.

10. Brunner, H.: Ueber das Verhalten der Mittelohrschleimhaut nach Radikaloperation. Acta oto-laryng. **15**:398, 1931.

11. Mayer, O., in discussion on Ruttin,[20] p. 352.

12. (*a*) Nager, F. R.: Demonstrations of Sections of a Patient with Otosclerosis, Acta oto-laryng. **26**:342, 1938. (*b*) Engström, H.: Ueber das Vorkommen der Otosklerose nebst experimentellen Studien über die chirurgische Behandlung der Krankheit, ibid., 1940, supp. 43.

13. Lempert, J.: Improvement of Hearing in Cases of Otosclerosis, Arch. Otolaryng. **28**:42 (July) 1938; Endaural Fenestration of External Semicircular Canal for Restoration of Hearing in Cases of Otosclerosis, ibid. **31**:711 (May) 1940; Fenestra Nov Ovalis, ibid. **34**:880 (Nov.) 1941.

14. Schmiegelow, E.: Beitrag zur pathologische Anatomie der unkomplizierten Labyrinthkapseldefekte, Ztschr. f. Ohrenh. **64**:146, 1912.

are omitted because in those cases there was still evidence of progressive destruction of the labyrinthine capsule.

In this paper a new case will be reported.

REPORT OF A CASE

J. H., a woman 46 years old, was admitted to the Presbyterian Hospital on Jan. 9, 1937. She had had diphtheria in childhood and chronic suppuration of the right middle ear since that time. Three years before her death she had undergone tympanomastoidectomy. At the time of her last admission the operative cavity was completely epithelized. Labyrinthine symptoms are not mentioned in her history. She died of rupture of the appendix with formation of a retrocecal and perinephric abscess.

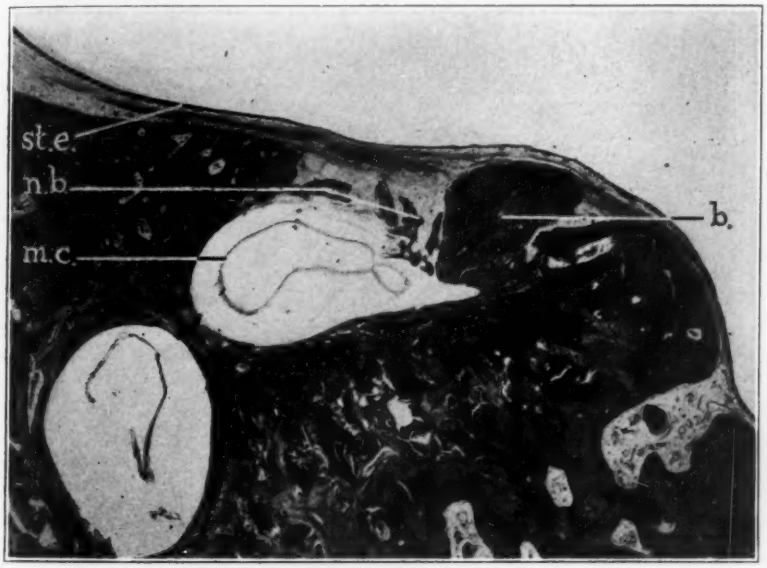

Fig. 1.—General view of the fistula: *b.*, piece of bone protruding into the perilymphatic space; *m. c.*, membranous lateral canal; *n. b.*, newly formed bone in the fistula; *st. e.*, stratified squamous epithelium covering the surface of the operative cavity.

Histologic Examination of the Right Temporal Bone (horizontal serial sections).—There was a large cavity after tympanomastoidectomy. It was lined with stratified squamous epithelium, which rested on a layer of rather dense connective tissue showing practically no inflammatory changes. Both window niches were filled with connective tissue containing many small epithelium-lined cysts. The stapes was well preserved. The prominence of the lateral semicircular canal was missing. In an area measuring 3 mm. in length and 0.75 mm. in width which extended from the ampullar end of the semicircular canal to the adjacent parts

15. Zumbroich, H.: Ein histologisch untersuchter Fall von Labyrinthkapsel-Lücke, Ztschr. f. Hals-, Nasen- u. Ohrenh. **4**:389, 1923.

of the ampulla itself and which lay directly under the lining membrane of the operative cavity the normal structure of the osseous wall had been interrupted (figs. 1 and 2). In the proximal part of this area (toward the ampulla) the enchondral and the endosteal layer ended at the periphery with a somewhat irregular borderline. The periosteal layer extended without a sharp border into a mass of bone which extended inward over the surface of the enchondral layer and narrowed considerably the defect in the canal. In the distal parts of this area (away from the ampulla) a rather large piece of bone was seen which showed exactly the same structure as the periosteal capsule. At its base it was connected

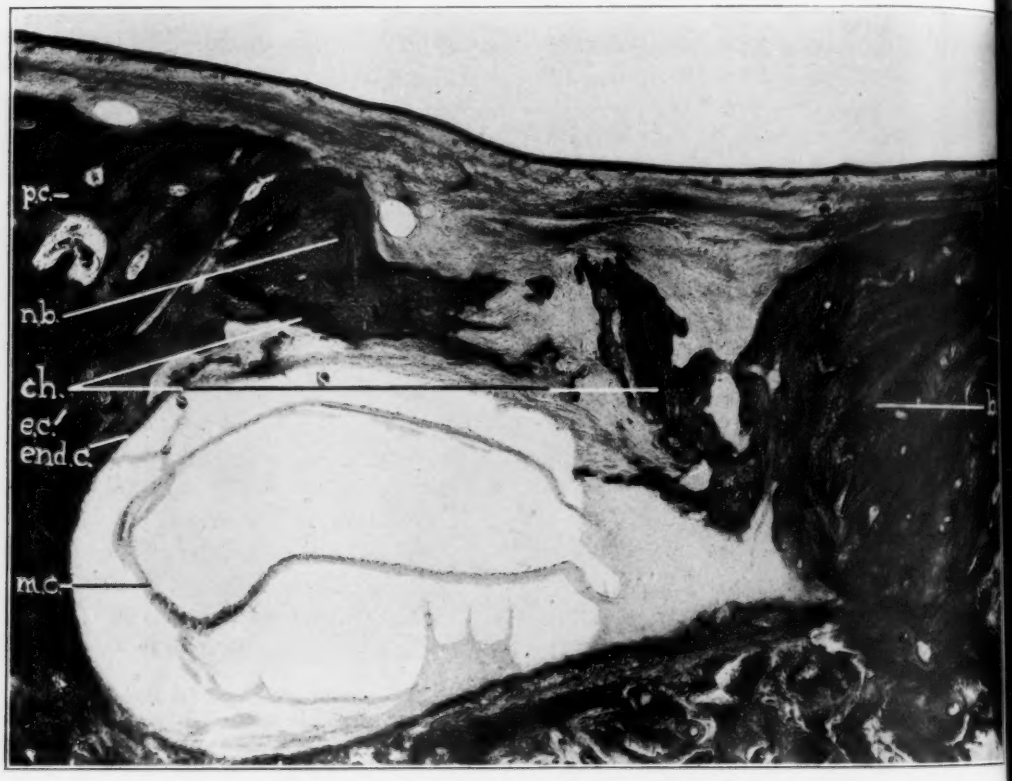

Fig. 2.—Fistula under higher power: *b.*, piece of bone protruding into the perilymphatic space; *ch.*, bone chips partially surrounded by newly formed bone; *e. c.*, enchondral layer; *end. c.*, endosteal layer; *p. c.*, periosteal layer; *m. c.* membranous canal; *n. b.*, newly formed bone in the fistula.

with the osseous wall of the canal, and its outer surface terminated in a sharp ridge which bulged into the membranous canal and compressed its lumen (fig. 3). The bony masses at the periphery narrowed the defect in the canal to an area measuring 1.25 by 0.5 mm. The defect itself was filled with moderately cellular and vascular connective tissue in which several chips of necrotic bone were embedded (fig. 2); these failed to show any evidence of present or past erosion. Some of them were completely, others partially, surrounded by a net-

work of newly formed weblike fibril bone which in many instances was connected with the bony masses at the periphery of the defect. There was a minimal amount of bone formation still going on in some of the bony spicules. Otherwise, the process had come to a complete standstill. Between the areas occupied by bone were left small spaces with walls remaining entirely membranous. Where the piece of bone described projected into the perilymphatic space, the outer half of the latter contained a network of weblike fibril bone which was connected with the endosteal layer of the capsule. It partially surrounded the piece of bone which projected from the outside into the perilymphatic space, and a few splinters of necrotic bone had found their way into this area. The new formation of bone

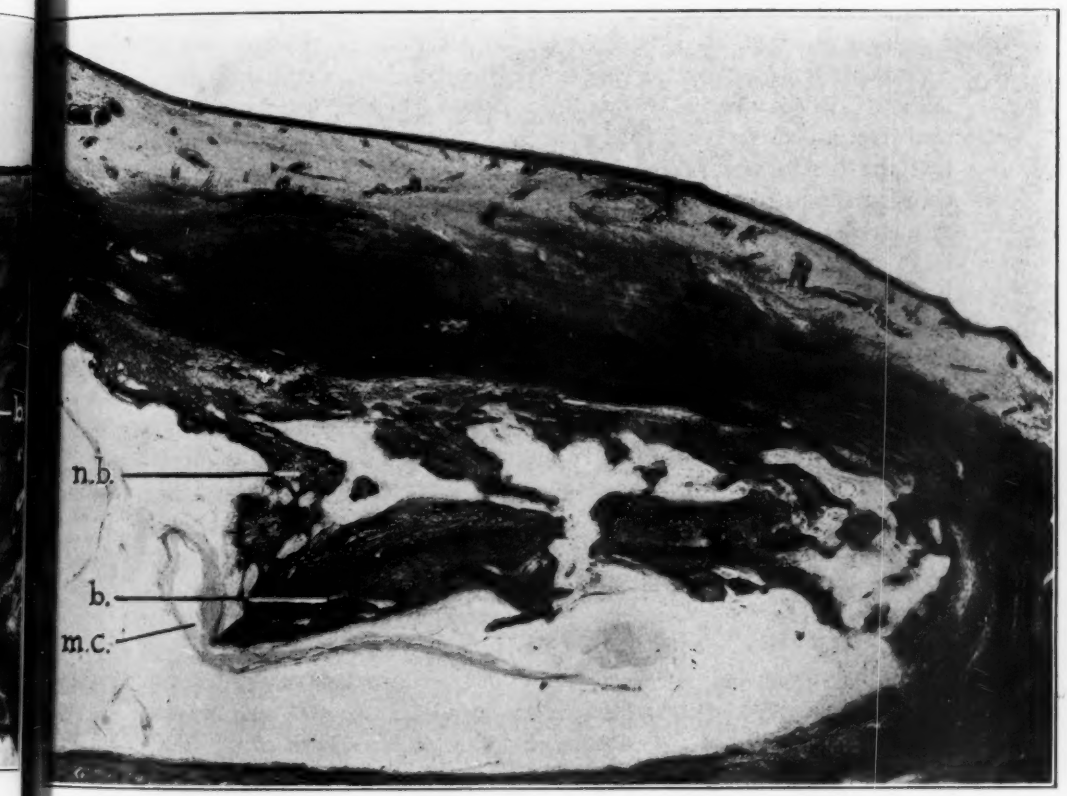

Fig. 3.—Newly formed bone in the proliferated perilymphatic tissue: *b.*, piece of bone protruding into the perilymphatic space; *m. c.*, membranous canal; *n.b.*, newly formed bone.

had already come to a complete standstill. The newly formed bone showed nowhere any evidence of internal reconstruction or residua from it. The other parts of the perilymphatic space, even in the region of the fistula itself, and the membranous labyrinth were free from pathologic changes. The internal auditory meatus appeared normal.

Summary.—A 46 year old patient had undergone tympanomastoidectomy on the right side three years before her death because of an ear which had been

discharging since childhood. The postoperative course had been uneventful, and the cavity was completely epithelized. Histologic examination showed a defect in the osseous capsule of the ampullar end of the lateral semicircular canal and in the adjacent parts of the ampulla which later had been closed partially by bone and partially by connective tissue. In a small area in the neighborhood of the fistula, the outer half of the perilymphatic space was filled in with connective tissue and bone, and the membranous canal was compressed by a piece of bone which protruded from the outside into the perilymphatic space.

COMMENT

It is difficult, often even impossible, to decide on the basis of the histologic observations alone whether a defect in the osseous wall of a semicircular canal is the result of disease or of operative trauma. Although in the case just described a detailed clinical history was not available, an analysis of the histologic picture permits the conclusion that the fistula was caused by operative trauma. The necrotic bone chips in the fistula and in the perilymphatic space were most probably splintered off from the wall of the canal during an operation. The large piece of bone which projected from the outside into the perilymphatic space was evidently a piece of the capsule which was pushed inward during the operation though not completely broken off.

Bone chips containing osteocytes still capable of staining were seen in an operative fistula by Hegener [2] two and one-half months after operation; a similar observation was made by Engström [12b] twenty-seven days after operation. Such chips have often been found after experimental fenestrations in animals (Engström; [12b] Fowler; [16] Perlman [17]).

The operative trauma had opened the perilymphatic space in a circumscribed area. Most probably the sharp edge of the large piece of bone which was broken off from the capsule had pierced the endosteum. This penetration was followed by circumscribed labyrinthitis. The defect in the osseous wall of the canal was filled in at first with connective tissue, and new formation of bone followed shortly afterward.

The formation of new bone had started in the area adjacent to the periosteal layer of the capsule. From vascular spaces of the latter which were opened by the operative trauma, vascular connective tissue had grown into the fistula and participated in the formation of the tissue which filled the operative defect. This makes the absence of a distinct borderline between the periosteal capsule and the newly formed bone easily understandable. Formation of a network of weblike fibril bone had likewise taken place in the proliferated connective tissue of the perilymphatic space. Other bone developed around bone chips.

16. Fowler, E. P., Jr.: Closure of Operative Fenestrae in the Labyrinth, Arch. Otolaryng. **34**:209 (Aug.) 1941.

17. Perlman, H. B.: Process of Healing in Injuries to the Capsule of the Labyrinth, Arch. Otolaryng. **29**:287 (Feb.) 1939.

The bone connected with the periosteal capsule is called by many authors periosteal, and the bone connected with the endosteal layer endosteal, bone. These terms, however, are misleading. The bone in this area is always formed within the connective tissue, which at certain places and under certain conditions assumes osteogenetic properties. The enchondral layer with its slow metabolism and the physiologic regressive changes in the vascular channels did not participate in the formation of the connective tissue in the fistula. Its histologic structure is so entirely different from that of the newly formed bone that the border between it and the newly formed bone always remains sharp.

The fact that the new formation of bone had come practically to a standstill in the form of weblike fibril bone and that the newly formed bone did not show any evidence of internal reconstruction seems noteworthy. According to Engström,[12b] in fistulas in monkeys osteoclastic destruction of the newly formed bone is almost completely absent, but nevertheless in old fistulas the bone shows clearly a lamellar strucure. He assumed that this change in the structure was the result of slow "rearrangement" of the fibrils within the bone and not of destruction of the weblike fibril bone followed by apposition of lamellar bone. It is hard to understand how such "rearrangement" could take place in the calcified intercellular substance. Lamellar bone was found in the human fistula by Preuss[8] (case 4). He expressed the belief that it had replaced the original weblike fibril bone.

In the case described in this paper only partial bony closure of the fistula had occurred, and it seems probable that the fistular test had remained at least slightly positive.

In only 4 of the 19 cases collected from the literature was the fistula unquestionably caused by an operative trauma (Hegener;[2] Zange,[6] case XV; Nager and Engström;[12] Lempert[13]) and in only 1 possibly so caused (Brunner[10]). In Hegener's case two and one-half months after operation the fistula was filled with connective tissue, which contained many bony splinters of the original capsule. There was new formation of bone at the margins of the defect and around the bone chips. The perilymphatic space in this area was filled with proliferated connective tissue. The membranous semicircular canal was adherent to the inner surface of the fistula and its lumen compressed.

In Zange's[6] case with labyrinthitis following otitis due to Pneumococcus type III the fistula three weeks after operation was filled with granulation tissue which extended inward into the lumen of the lateral canal. In its outer part and toward the middle ear the fistula was closed by new bone.

In the case of Nager and Engström,[12] twenty-seven days after fistulization of the lateral and posterior vertical canals the fistulas were filled with connective tissue and some bone chips. There was new formation of bone in the connective tissue within and around the fistula,

starting around the margins and progressing toward the center, and also around the bone chips. Inside of the fistular opening proper a thin layer of bone had formed, which followed the endosteum and extended for a short distance into the lumen of the canal. There was proliferation of the perilymphatic tissue in the area of the fistula. The membranous canals were practically intact. In the case of Lempert,[13] fourteen days after operation the fistula in the lateral canal was covered with the tympanomeatal membrane. New bone formation was completely absent. The perilymphatic spaces contained blood, and there was proliferation of connective tissue in the area of the fistula. The membranous canal was surrounded by the proliferated tissue and was adherent to the tympanomeatal membrane within the fistula.

In the case of Brunner [10] tympanomastoidectomy had been performed twelve years before the patient's death. In the horizontal canal was a fistula which was closed mostly by bone but partially by connective tissue. The perilymphatic space was filled with connective tissue and bone.

In 13 of the 14 cases of nontraumatic fistula, the presence of cholesteatoma had been proved; in 1 case (Zange and Grünberg) no clinical data were available. In 12 cases the lateral canal alone was affected; in 1 case (Preuss,[8] case 3) the lateral and the superior vertical canal. In 6 of them (Zange-Grünberg;[6] Brock [7] [1921]; Preuss,[8] cases 1, 2 and 4; Mayer and Beyer [9]) the fistula was completely closed, while in 3 others it was in the process of closure (Zeroni;[1] Brock [5] [1912], 2 cases). In 5 (Wagener [3] [1909, 1910]; Habermann [4]; Preuss,[8] case 3; Mayer [11]) the fistula had stayed open without any evidence of new formation of bone.

The histologic changes in the cases of bony closure of a nontraumatic fistula are essentially identical with those found in the postoperative fistula. When the endosteum had been destroyed, the bony masses often extended into the perilymphatic space. The latter, as a rule, reacts to the destruction of the endosteum with a circumscribed granulating inflammation which in many instances leads to complete filling of the lumen with connective tissue; the membranous canal becomes adherent to the inner surface of this connective tissue. In many instances new formation of bone occurs within the proliferated perilymphatic tissue, but the amount of this bone is again always much smaller that that of the bone formed within the fistula proper.

Tissue proliferation within the perilymphatic space occurs sometimes even with intact endosteum. This is seen in cases 1 and 4 of Preuss [8] and in that of Zumbroich.[15] In the latter's case even bone formation had started within the proliferated perilymphatic tissue. As a rule, however, the changes within the perilymphatic space are much more marked when the endosteum is extensively damaged.

The cases in which the fistula had stayed open for a long time had several features in common. The bone apparently had been destroyed very gradually and with a minimum degree of irritation by a slowly growing cholesteatoma; the outer surface of the fistula was covered with stratified squamous epithelium, and the tissue within the fistula was practically free from inflammatory changes. In 2 cases (Wagener;[3b] Habermann[4]) the endosteum did not show any reaction; in 1 (Wagener[3a]) it was considerably thickened. In Mayer's[11] case no data were available. In all these cases the perilymphatic space itself was completely free from changes. In case 3 of Preuss[8] two fistulas were present. One was small and situated in the superior vertical canal just above the ampulla; the other was large and extended from the prominence of the lateral canal forward and well over the ampulla. The fistula in the superior canal was completely closed with bone, which protruded into the lumen, while the fistula in the lateral canal was closed with bone in its posterior half only, and the lumen in this area was completely obliterated. In the anterior part, over the ampulla, however, the defect was closed with a thin layer of connective tissue only. The upper, the lateral and a part of the lower wall of the osseous facial canal were completely missing. Within the labyrinthine cavities there was evidence of healed serous labyrinthitis, such as dilatation of the ampullar part of the lateral canal and of the cochlear duct, degenerative changes of the end-organs and bone formation in the scala tympani. Evidently in this case so-called diffuse serous secondary labyrinthitis had developed from circumscribed granulating internal otitis and had healed with typical residua.

An analysis of all the reported cases brings out certain factors which tend to promote, and others which tend to retard, bone formation within the fistula.

The most important inciting factor is the presence of highly vascularized and cellular tissue in the fistula, because this is the stratum in which new formation of bone is most likely to occur. Among the conditions which incite the development of this tissue, infection must first be mentioned (Lempert). This is well seen in Zange's[6] case in which the fistula was closed after three weeks. Fracturing inward and microfissures of the surrounding bone and bleeding into the fistula with subsequent organization of the coagulums are other conditions to be considered. Mesenchymal tissue grafts, such as connective tissue, fat and muscle tissue, placed into the fistula eventually degenerate and become organized. All these are stimuli for the formation of cellular tissue with osteogenetic propensities. This was shown by Engström[12b] in experimental fistulas in monkeys. The role played by missed bone chips as centers of bone formation in operative fistulas is well known and hardly needs further discussion (Fowler;[16] Engström[12b]).

Only one interesting fact will be mentioned. In contrast to the findings in other regions, there is little evidence of resorption of the bone chips. Surrounded by newly formed bone, they were still present after three years in the case described in this paper. Similar observations were made by Engström [12b] in monkeys one year after operation.

Observation of the reparatory changes in diffuse serous and purulent labyrinthitis shows a marked tendency toward bone formation within the proliferated connective tissue which fills in the labyrinthine cavities. The distribution of the newly formed bone shows, according to Görke,[18] some degree of regularity. Whereas the basal turn of the cochlea and the semicircular canals are often completely filled in with new bone, the vestibulum usually shows only an insignificant amount of new bone formation. It is more frequently filled with connective tissue.

The same tendency toward bone formation, with the same local differences in intensity, prevails in the connective tissue which is formed in the course of circumscribed labyrinthitis.

Bleeding into the perilymphatic space following traumatization of the endosteum, with subsequent organization of the masses of blood, is another significant factor (Lempert [13]).

The only factor which actually seems to delay or prohibit new formation of bone is the presence of epithelium on the outer surface of the fistula. Its significance has been stressed by several authors, such as Engström,[12b] Fowler,[16] Lempert [13] and Sourdille.[19] The main effect of the epithelium is probably that of protecting the underlying tissue from infection or other irritation. A reduction in the intensity of the inflammatory changes within the fistula could well lead to a reduction in the new formation of bone in this area. Stratified squamous epithelium is unquestionably more effective in this respect than columnar epithelium. This is well seen in cases of chronic transformative otitis media in which stratified squamous epithelium grows from the external canal into the middle ear and replaces the cuboidal or columnar epithelium. The areas covered by squamous epithelium show a marked reduction in the inflammatory infiltration of the subepithelial tissue layers with a tendency toward fibrosis of the latter.

Summarizing, one may say that hemorrhage and infection in the area of the fistula and bone chips left behind are the most important factors that promote bony closure of the fistula. The presence of epithelium on the outer surface of the tissue which fills out the defect in the bone, particularly of stratified squamous epithelium, exerts a retarding influence.

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18. Görke, M.: Die entzündlichen Erkrankungen des Labyrinthes, Arch. f. Ohrenh. **80**:1, 1909.

19. Sourdille, M.: New Technique in the Surgical Treatment of Progressive Deafness from Otosclerosis, Bull. New York Acad. Med. **13**:673, 1937.

If one tries to correlate the previously mentioned facts with the experience gained during fenestration operations for otosclerosis, the following can be said: The importance of carefully removing all the bone chips from the fistula and of preventing excessive postoperative inflammatory reaction is confirmed by the observations of human temporal bones. In the cases in which the nontraumatic fistula had stayed open, the endosteum had remained practically intact, and there was no, or very little, inflammatory reaction in the perilymphatic space. Experience in fenestration operations (Lempert [13]), however, shows that when the fibrous endosteal membrane was left intact, rapid closure by bone formation occurred in the vast majority of cases. The apparent difference in the behavior of the endosteum in spontaneous and operative fistulas is explained by the following facts: In operative fistulas bleeding into the narrow space between the endosteum and the flap which covers the fenstra occurs, and some inflammatory reaction in the flap is unavoidable. Exudation of serum, fibrin, leukocytes and other elements occurs, which is followed by reactive inflammatory changes in the endosteum and by formation of a connective tissue matrix, which rapidly assumes osteogenetic propensities, within the fistula.

In spontaneous fistulas, which develop slowly, inflammatory changes are practically absent, and when in the course of the destruction caused by a cholesteatoma the endosteum is eventually reached, the process comes to a standstill.

The best results were obtained when the endosteum was completely removed and the inner endosteal cambium layer underneath the inner margins of the bony walls of the fistula was shaved. However, in cases of this type some inflammatory reaction in the perilymphatic space is unavoidable. As long as it is of limited intensity it evidently does not interfere much with the function of the fistula. The difficulty is that the newly formed tissue gradually fills in the fistula and eventually ossifies partially and often completely. According to Lempert,[13] the tissue proliferation takes place mainly in response to the blood entering the perilymphatic space, and its intensity depends on the size of the perilymphatic space in the region of the fistula. In a large space the masses of blood are more easily disseminated, absorbed and eliminated than in a small space. In the latter they are more likely to remain and stimulate tissue proliferation. In support of this opinion, Lempert mentioned his observation that in operative fistulas which extend forward well over the ampulla excessive tissue proliferation leads to bony closure only in the posterior part, the part which overlies the narrow canal, not in the anterior part which overlies the wider ampulla. The findings in case 3 of Preuss,[8] in which the fistula of the lateral semicircular canal was closed with bone in the posterior half but only with connective tissue in the region of the ampulla, are in

good agreement with Lempert's observations. In a case of Ruttin [20] a fistula had remained partially open thirteen years after tympanomastoidectomy for cholesteatoma. Here, again, the posterior part was closed with hyperostotic bone while the anterior part, close to the ampulla, contained only connective tissue.

In addition to the size of the perilymphatic space, the differences in the osteogenetic activity of the newly formed connective tissue in the various parts of the labyrinth, as mentioned by Görke,[18] may determine whether a fistula will close with bone or with connective tissue.

No matter what the final explanation may be, by creating the fistula in the surgical dome of the vestibule where the perilymphatic space is wide and the osteogenetic activity low, Lempert [13] was apparently able to reduce considerably the incidence of postoperative bony closure of the fistula. The anatomic findings and the good results obtained with this method refute the assumption of Engström [12b] that new bone would grow into the ampulla and damage the sensory epithelium of the crista. To create the window away from the ampulla, over the prominence of the lateral canal, as suggested by Fleischmann [21] on the basis of this assumption, seems not justified.

The role played by epithelium, particularly stratified squamous epithelium on the outer surface of the fistula, in the reduction of the intensity of the inflammatory reaction within the fistula has already been discussed.

According to Lempert,[13] not only the outer but the inner surface of the flap which is laid over the fistula ("tympanomeatal membrane") should be covered with epithelium. This can be achieved when the surgical dome of the vestibule is fenestrated, because then there is a good chance that the fistula ("fenestra nov-ovalis") can be completely covered with Shrapnell's membrane. The epithelium-lined inner surface coming in contact with the coagulum will, in Lempert's [13] opinion, counteract the organization of the blood clot and its eventual transformation into connective tissue. The other parts of the tympanomeatal membrane show a periosteum-lined inner surface, and when the latter covers the fistula and comes in contact with the coagulum, the formation of fibrous connective tissue might be stimulated.

It remains to be seen whether the epithelium on the inner surface of the flap really is essential, because in all probability the epithelium when brought in contact with the fistula will degenerate within a short time. It is, moreover, well conceivable that another factor is of greater importance, i.e., the thickness of the flap. Shrapnell's membrane is

20. Ruttin, E.: Bindegewebig geheilte Bogengangsfistel, Monatschr. f. Ohrenh. **72**:350, 1938.

21. Fleischmann, L.: Beiträge zur chirurgischen Behandlung der Otosklerose, Acta oto-laryng. **30**:139, 1942.

thin and relatively poor in vessels; the skin from the upper meatal wall is thicker and well vascularized. When Shrapnell's membrane or cicatricial tissue from the upper meatal wall (Sourdille [19]) covers the fistula, organizing or inflammatory changes developing in or from such a flap will undoubtedly be much less prominent than those in a flap taken from the normal upper meatal wall.

SUMMARY AND CONCLUSIONS

An incomplete bony closure of a fistula of the lateral semicircular canal was observed three years after operative injury.

The findings in this case were analyzed and compared with those in 19 cases collected from the literature.

In the cases in which a spontaneous fistula had stayed open, the bone had been destroyed very gradually and with a minimum degree of irritation by a slowly growing cholesteatoma. The outer surface of the fistula was covered with stratified squamous epithelium, and the endosteum was normal or thickened but not destroyed.

Infection and hemorrhages in the area of the fistula, destruction of the endosteum and presence of bone chips left behind are the most important factors that promote bony closure of the fistula. Epithelium on the outer surface of the fistula, particularly stratified squamous epithelium, exerts a retarding influence on bone formation.

In contrast to the findings in spontaneous fistulas, rapid bony closure of the vast majority of the fistulas created in fenestration operations took place when the fibrous endosteal membrane had been left intact. This is explained by the fact that in operative fistulas there is an accumulation of blood and inflammatory exudate in the narrow space between the endosteum and the skin flap with subsequent formation of osteopoietic tissue. In spontaneous fistulas these changes are absent, and the process comes to a standstill when the endosteum has been reached.

The experience gained in fenestration operations, particularly the observation that the fistula in the ampulla of the lateral canal or in the surgical dome of the vestibule shows less tendency to bony closure than one over the canal proper, is confirmed by the anatomic findings in some cases of nontraumatic fistula. The correlations and the differences are explained not only by the effects of the larger size of the perilymphatic space in the vestibule but also by the local differences in the osteogenetic activity of the newly formed connective tissue in various parts of the labyrinth.

630 West One Hundred and Sixty-Eighth Street.

Abstracts from Current Literature

Ear

MEDICAL FOLLOW-UP OF HEARING TESTS. COURTNEY D. OSBORN, J. Speech Disorders **10**:261, 1945.

Two audiograms were taken a year apart for each of 248 children with 327 ears showing hearing loss who had received no medical attention previous to a hearing conservation program. The group was divided into two parts, those who received medical attention afterward and those who did not. The first and second audiograms were analyzed to compare gains and losses. Of the group receiving medical treatment after the case-finding program, 85 per cent showed improvement in hearing, 65 per cent of them to the range of "normal" hearing. Of the group receiving no medical treatment, 23 per cent showed some improvement in hearing, 11 per cent of them to the range of "normal" hearing. Only 14 per cent of the group receiving medical treatment showed no change in hearing loss, and none of them had a greater loss at the second testing. Of the group that received no medical treatment, 76 per cent retained the same, and 22 per cent showed a greater, loss of hearing at the second testing. This indicates that hearing of school children can be conserved through careful testing programs with emphasis on medical follow-up. Osborn believes that public education in hearing conservation is badly needed, and should be the primary objective in a hearing conservation program.

PALMER, Wichita, Kan.

PHYSICS OF THE CONDUCTION APPARATUS. H. B. PERLMAN, Laryngoscope **55**:337 (July) 1945.

The physics of the conduction apparatus is not well understood. Acoustic movements of various parts of the apparatus can be studied in fresh temporal bones by the use of minute mirrors. These are attached to the parts to be studied. Any movement of the beam of light reflected from the mirror is recorded by a camera some distance away (affording great amplification of the movement).

By such means, the following were studied: resonance frequency, the damping factor, the effective mass (of the conducting parts), distortion, and the action of the middle ear muscles.

HITSCHLER, Philadelphia.

REACTION OF THE HUMAN CONDUCTION MECHANISM TO BLAST. H. B. PERLMAN, Laryngoscope **55**:427 (Aug.) 1945.

Perlman discusses the effects of blasts on the ear. Blasts of various kinds produce certain changes of pressure. These changes cause ossicular movements. The movements of the ossicles in fresh temporal bones are measured and recorded by means of a beam of light reflected to a camera from a mirror attached to an ossicle. The clinical significance of such blasts and the means of avoiding the trauma caused by them are pointed out.

HITSCHLER, Philadelphia.

TREATMENT OF MÉNIÈRE'S SYNDROME. JOHN J. RAINEY, New York State J. Med. **45**:1753 (Aug. 15) 1945.

Rainey states that diagnosis of Ménière's syndrome is not so easy as it seems. The condition has been mistaken for disease of the gallbladder and for craniocerebral trauma. The cause is a disturbance of the inner ear which is produced by a sudden release of histamine. Therefore, one should "desensitize" by giving

intravenous injections of histamine phosphate. This author does not agree with Atkinson that the cases may be divided into vasoconstrictor or vasodilator types, and he does not believe that cutaneous tests can decide the issue. ". . . some neurosurgeons claim . . . 90 per cent of the patients have unilateral nerve deafness. Our experience is just the reverse. Less than 20 per cent have unilateral nerve disease." Resort to surgery is therefore of doubtful value and may be contraindicated. "Many great figures in history have been victims, among whom was Ludwig von Beethoven." Now Ménière lived between 1799 and 1862. Beethoven's span was from 1770 to 1827. His deafness seems to date from about 1798, and it became progressively worse. Nowhere in his medical history so far as this reviewer has penetrated is Ménière's disease mentioned, and it is distinctly not named in the postmortem report. The guess is a reasonable one, but it is a guess only and not an established fact. Rainey cites briefly 5 personal observations. He then says, "It is questionable whether any patient ever had his hearing improved by administration of histamine. Tinnitus is improved in many instances but, again, there may be a resurgence." The value of being studied by "a private physician" is stressed as opposed to being examined in "a large clinic." If the diagnosis is correct, one has "in histamine phosphate, used intravenously, a treatment that will give prompt relief in the majority of cases."

VOORHEES, New York.

OTITIS EXTERNA. J. F. BIRRELL, Brit. M. J. **2**:80 (July 21) 1945.

On the basis of nearly 1,000 cases of otitis externa observed in the army, the author makes a number of recommendations. Meatal congestion may be caused by (1) irritants which enter the meatus from the middle ear, (2) the natural secretions of the meatus, (3) irritants entering the canal from the outside, (4) general conditions predisposing to cutaneous infections or (5) local or general allergy. In this series Pseudomonas pyocyanea was the predominant organism in nearly every case in which bacteriologic studies were made. The prognosis in any attack of otitis externa was good: In 60 to 70 per cent of the cases there was healing within a week. However, relapses were common, and frequent recurrences or lack of early treatment led to chronicity, which, once established, made cure of the disease almost impossible. Treatment is based on two procedures: first, thorough cleansing from the meatus of all particles of discharge, and second, application of lotions to the inflamed meatal walls. Drugs should be applied on wicks of ribbon gauze or painted on by means of wool-tipped wire probes. Cotton should not be used. In the acute edematous conditions the author prefers ichthammol (10 per cent) in hypertonic solution of sodium chloride. He recommends ichthammol (10 per cent) in glycerin to be used after forty-eight hours of treatment until there is no further exudation. At this point, silver nitrate (1 per cent) or an alcoholic solution (1 per cent) of gentian violet medicinal should be used to harden the meatal skin.

Associated dermatitis of the auricle is best treated with ammoniated mercury (1 per cent) in paste of zinc oxide applied on spreads and molded to the pinna. Penicillin is of little value, since in most cases the disease is caused by a mixed infection.

The patient is instructed not to scratch the ear, however itchy, and not to let water enter the meatus during washing. Sea bathing is forbidden.

SHAW, Chattanooga, Tenn. [ARCH. DERMAT. & SYPH.]

THE ROLE OF SACCUS ENDOLYMPHATICUS IN INFLAMMATION. J. P. SECRÉTAN, Pract. oto-rhino-laryng. **6**:1, 1944.

In this work the role of the saccus endolymphaticus, as it reacts to infection, is evaluated particularly in regard to the relationship of meningitis and labyrinthitis. The author's conclusions follow: 1. In mild otitis media the saccus endolymphaticus reacts, as revealed in one third of his cases, by true proliferation of the intrasaccular free cells with increase of the phagocytes. If the proliferation of

the intrasaccular free cells occurs quickly and there is an increase of their processes it prevents infection being transmitted from the labyrinth to the meninges through the aqueductus vestibuli; thus the saccus endolymphaticus appears to have an antitoxic function. In mastoiditis and meningitis without a labyrinthine involvement the saccus endolymphaticus, as shown in 70 per cent of the cases, presents a serous exudate. Contrariwise, in the labyrinthitis without an involvement of the meninges or of the neighboring mastoid cells, this exudate appears less frequently—in only 15 per cent of the cases examined. This differentiation speaks for a vascular influence. The ductus endolymphaticus rarely transmits a terminal empyema of the saccus endolymphaticus. Transmission of infection from the labyrinth to the meninges by way of the aqueductus vestibuli cannot be established. (He was never able to establish the residue of an inflammatory reaction in the saccus endolymphaticus, but in meningitis there occurred an infiltration of the perisaccular tissue, following which there could develop a residual sclerotic change.)

2. The aqueductus cochleae often serves as a pathway by which infection extends from the meninges to the labyrinth. This pathway, however, has only a secondary significance. On the other hand, it appears that only with great difficulty can the cochlear fluid transmit infection from the labyrinth to the meninges, for in the aqueduct there occur free phagocytic cells which combat the infection as do those cells in the saccus endolymphaticus. It is also possible that the direction of perilymph flow in the aqueductus cochleae has an important role. The blood flow in the canal of Coptugno seems to be reversed. This canal becomes infected early in otogenous labyrinthitis but remains intact for a long time. When the infection originates in meningitis, this process probably is due to the direction of the blood flow in the canal, for the blood flows in a direction opposite to that of the perilymph in the aqueductus cochleae.

3. The internal acoustic meatus most frequently serves as a route for infection extending from the labyrinth to the meninges and vice versa; this was observed in 100 per cent of the cases.

PERSKY, Philadelphia.

Pharynx

PENICILLIN PASTILLES FOR ORAL INFECTION. A. B. MACGREGOR and D. A. LONG, Brit. M. J. **2**:686 (Nov. 25) 1944.

Penicillin included in a pastille under suitable conditions is liberated in the mouth in an active form, and the concentrations in the mouth can be maintained without ill effects.

Acute ulcerative gingivostomatitis (Vincent's type) is simply, quickly and effectively treated in this manner. When this disease was treated in the acute stages, no recurrences were seen over a three and one-half month follow-up period.

Acute hemolytic streptococcus tonsillitis seemed to respond clinically to treatment with pastilles containing penicillin.

SHAW, Chattanooga, Tenn. [ARCH. DERMAT. & SYPH.]

Larynx

PAPILLOMATOSIS OF THE LARYNX IN CHILDHOOD. C. F. FERGUSON and H. W. SCOTT, New England J. Med. **230**:477 (April 20) 1944.

Fifteen patients with laryngeal papillomatosis were treated at the Children's Hospital in Boston during the ten year period 1933 through 1942. Papilloma is the commonest tumor of the larynx in childhood. It is a benign, self-limited growth that tends to recur but also to disappear at puberty. According to Crowe and Breitstein, the mortality from laryngeal papilloma in children under 5 years equals and possibly exceeds that from carcinoma of the larynx in adults. The incidence of laryngeal papilloma as estimated from the literature is approximately 1 case per thousand clinic patients. In this series it has an incidence of approxi-

mately 1:6,000. According to Gerhardt, in about one fifth of all cases the condition is congenital.

The symptoms produced are hoarseness, aphonia, stridulous breathing, dyspnea and, later, the signs of increasing laryngeal obstruction. At the Children's Hospital the method of choice in the treatment of laryngeal papilloma is that of repeated endolaryngeal excision. In 8 of the 15 reported cases, there were excellent clinical cures, each patient having a normal voice and a normal larynx. Three patients are still under treatment, and only 1, who was discharged as normal five years ago and is now 17 years of age, has had a recurrence. Three patients died, 2 as a result of asphyxia at home and 1 of laryngeal diphtheria. Only 1 of these deaths was directly attributable to the papilloma.

GENGENBACH, Denver, Colo. [AM. J. DIS. CHILD.]

Nose

NASAL ALLERGY AND THE PRACTICING RHINOLOGIST. GEORGE E. SHAMBAUGH JR., Ann. Otol., Rhin. & Laryng. **54**:43 (March) 1945.

Shambaugh states that at least 70 per cent of chronic sinus infections and at least 90 per cent of chronic nasal infections can be shown to have an underlying allergic factor, which is responsible for the chronicity; consequently the best therapeutic results are secured by combining allergic treatment with treatment of the infection, and he advocates that the rhinologist make his own allergic studies. The diagnosis of nasal allergy is made by considering the history, the nasal smears, the cutaneous tests, the results of the elimination diet and the therapeutic test. Intradermal tests are more satisfactory than scratch tests, and he has learned to attach more significance to a slightly positive reaction to a food when all the rest of the tests are negative than to a strongly positive one when there are strong positive reactions to many substances; he has also learned that reactions to such foods as chocolate, coffee, wheat, milk and egg are more apt to be significant than an equally positive reaction to a fruit or a vegetable. The skin tests must be regarded as an aid but not as an index of the diagnosis. House dust is a major factor in most cases. Treatments are outlined, and instructions for the preparation of a dust-free room are given.

M. V. MILLER, Philadelphia.

RHINOSPORIDIUM SEEBERI WITH A REPORT OF SIXTEEN CASES. M. HABIBI, Pract. oto-rhino-laryng. **6**:35, 1944.

The author discusses the incidence, the pathologic aspects and the treatment of infection with Rhinosporidium Seeberi, a parasite belonging to the class Phycomycetes. It is commonly found in man and animals (horse and cattle). Its distribution is principally in South America, Ceylon, Africa and Persia. It occurs most frequently in males. The parasite produces tumors in the nose and the eyelids, which appear more or less polypoid and vary in size from a rice kernel to a hazelnut. The treatment advocated is extirpation of the tumors and electrocoagulation of the bases and the adjacent areas.

PERSKY, Philadelphia.

Miscellaneous

HISTAMINE CEPHALALGIA AND MIGRAINE. LOUIS E. LIEDER, Ann. Int. Med. **20**: 752 (May) 1944.

Lieder studied 71 consecutive patients with headache, devoting special attention to the question of allergy. Analysis of the cases showed that 4 patients had histamine cephalalgia, 52 had typical migraine and the remaining 15 had other types of headache, such as so-called hypertensive cephalalgia and anxiety states. Twenty-eight (54 per cent) of the 52 patients with migraine had food allergy. Twenty-three (44 per cent) of the migrainous patients had allergies such as so-called hay fever,

urticaria and asthma. A family history of some allergic manifestation or of migraine was obtained from 40 patients (77 per cent). The author concludes that "hypersensitivity plays a major role in causing migraine."

Desensitization with histamine was found to be of value in the successful treatment of patients with histamine cephalalgia. Ergotamine tartrate was recommended for the treatment of migraine, and the prophylactic and therapeutic use of prostigmine bromide and inhalation of oxygen were mentioned.

Lieder stresses the fact that the elimination of offending allergens is of utmost importance in the prevention of migraine.

GUTTMAN, Philadelphia. [ARCH. NEUROL. & PSYCHIAT.]

FURTHER OBSERVATIONS ON THE PRESENCE OF POLIOMYELITIS VIRUS IN THE HUMAN ORO-PHARYNX. HOWARD A. HOWE, DAVID BODIAN and HERBERT A. WENNER, Bull. Johns Hopkins Hosp. **76**:19 (Jan.) 1945.

Howe, Bodian and Wenner report observations on 36 patients who had poliomyelitis. Intracerebral inoculation of rhesus monkeys with inoculum from the oropharynx was employed. The criterion of successful isolation of the virus was the production of flaccid paralysis with typical lesions in the spinal cord of the experimental animals, or the production of indubitable lesions alone (1 case).

Virus was recovered from the oropharynx of 10 animals, or 28 per cent. Virus was present in 43 per cent of a series of 23 patients from whom swab specimens were taken during the first three days of the illness. In none of the series of 13 cases in which specimens were obtained after the third day of illness was the virus isolated.

GUTTMAN, Philadelphia. [ARCH. NEUROL. & PSYCHIAT.]

GERMAN-ENGLISH SPEECH TERMINOLOGY: A GUIDE FOR THE RESEARCH WORKER IN THE FIELD OF GERMAN LOGOPEDICS. MARY COATS-LONGERICH and EDWARD B. LONGERICH, J. Speech Disorders **10**:39 (March) 1945.

This is a brief dictionary of common German terms used in the logopedic field.

PALMER, Wichita, Kan.

CAVERNOUS SINUS THROMBOSIS WITH RECOVERY: REPORT OF CASE. A. J. HERZIG, Laryngoscope **55**:318 (June) 1945.

Herzig gives a brief review of the anatomy of the cavernous sinus and presents a case in which recovery was based on sulfadiazine therapy and supportive treatment.

HITSCHLER, Philadelphia.

THE THERAPY OF HISTAMINE AND NICOTINIC ACID. JOHN J. SHEA, Laryngoscope **55**:325 (July) 1945.

Certain kinds of headache, vertigo, tinnitus and deafness are caused by vasoconstriction affecting the auditory nerve and the cerebral vessels. Histamine and nicotinic acid are vasodilators and as such may relieve these conditions.

Histamine cephalgia is unilateral with sudden onset. It involves the temple, the eye and, at times, the face and the neck. The attacks are usually sharp and severe. The differential points between this, neuralgia and migraine are given. Dosage is discussed. Histamine is also used in the treatment of Ménière's disease and allergy in general.

Nicotinic acid (not nicotinamide) is sometimes of value in place of histamine. Shea feels that there is no definite indication for choosing nicotinic acid rather than histamine, and each patient must be observed for signs of improvement in order to decide which to use. (Atkinson uses histamine only in the histamine-positive group; he uses nicotinic acid in the others.—W. H.)

A combination of histamine and globulin, called hapamine, has been recently used. No histamine-like reactions are produced. It is of value in the treatment of certain allergic conditions, particularly in those of unknown cause.

HITSCHLER, Philadelphia.

THE HEALING PROCESS IN WOUNDS OF THE BRAIN. A. H. BAGGENSTOSS, J. W. KERNOHAN and J. F. DRAPIEWSKI, Proc. Staff Meet., Mayo Clin. **19**:419 (Aug. 9) 1944.

The studies reported by Baggenstoss, Kernohan and Drapiewski were made at necropsies in 70 selected cases in which ventricular puncture had been made for diagnostic purposes. It was found that repair was more vigorous in the cortex than in the white matter. Astrocytes were found to play a minor role in the reparative process, and actual participation of these cells in the formation of a scar was not observed in wounds of less than six months' duration. When repair took place, the predominant role was played by mesodermal elements—capillaries, endothelium, fibroblasts and leukocytes. Microglia cells appeared to have only a small part in the production of compound granular corpuscles. Most of the latter seemed to have their origin in the endothelial cells associated with capillaries, in the adventitial cells of the larger blood vessels and in the mononuclear cells of the circulating blood.

ALPERS, Philadelphia. [ARCH. NEUROL. & PSYCHIAT.]

News and Comment

FIRST PAN-AMERICAN CONGRESS OF OTO-RHINO-LARYNGOLOGY AND BRONCHO-ESOPHAGOLOGY

Immediately following and overlapping with the annual meeting of the American Academy of Ophthalmology and Otolaryngology in October of this year, the First Pan-American Congress of Oto-Rhino-Laryngology and Broncho-Esophagology will take place, under the sponsorship of the Academy. This congress will open with a banquet and evening session on Thursday night, October 17, and will continue on the two subsequent days. The first scientific session will be a joint session with the oto-laryngology section of the Academy, and three additional sessions will take place on Friday afternoon, Saturday morning and Saturday afternoon. All interested members of the Academy are strongly urged to plan on remaining for the Pan-American Congress, for which an excellent program is being arranged.

The registration fee will be $5.

EXECUTIVE COMMITTEE, PAN-AMERICAN CONGRESS
GORDON B. NEW, M.D., *President*
CHEVALIER L. JACKSON, M.D., *Secretary*
PAUL H. HOLINGER, M.D., *Treasurer*

Directory of Otolaryngologic Societies *

INTERNATIONAL

First Pan-American Congress of Oto-Rhino-Laryngology and Bronchoesophagology

Predident: Dr. Gordon B. New, Mayo Clinic, Rochester, Minn.
Secretary: Dr. Chevalier L. Jackson, 255 S. 17th St., Philadelphia 3.
Place: Palmer House, Chicago. Time: Oct. 17-19, 1946.

NATIONAL

American Medical Association, Scientific Assembly, Section on Laryngology, Otology and Rhinology

Chairman: Dr. Louis H. Clerf, 1530 Locust St., Philadelphia.
Secretary: Dr. Fletcher D. Woodward, 104 E. Market St., Charlottesville, Va.
Place: San Francisco. Time: July 1-5, 1946.

American Academy of Ophthalmology and Otolaryngology

President: Dr. Gordon B. New, Mayo Clinic, Rochester, Minn.
President-Elect: Dr. Alan C. Woods, Johns Hopkins Hospital, Baltimore 5.
Executive Secretary-Treasurer: Dr. William L. Benedict, 100–1st Ave. Bldg., Rochester, Minn.
Place: Palmer House, Chicago. Time: Oct. 13-18, 1946.

American Broncho-Esophagological Association

President: Dr. Carlos E. Pitkin, Carnegie Medical Bldg., Cleveland.
Secretary: Dr. Paul Holinger, 700 N. Michigan Ave., Chicago 11.
Place: Drake Hotel, Chicago. Time: May 31, 1946.

American Laryngological Association

President: Dr. Harold I. Lillie, Mayo Clinic, Rochester, Minn.
Secretary: Dr. Arthur W. Proetz, Beaumont Bldg., St. Louis.
Place: Drake Hotel, Chicago. Time: May 29-30, 1946.

American Laryngological, Rhinological and Otological Society, Inc.

President: Dr. Albert C. Furstenberg, University Hospital, Ann Arbor, Mich.
Secretary. Dr. C. Stewart Nash, 708 Medical Arts Bldg., Rochester 7, N. Y.
Place: Drake Hotel, Chicago. Time: May 27-28, 1946.

SECTIONS:

Eastern.—Chairman: Dr.Philip E. Meltzer, 20 Charlesgate West, Boston 15.
Southern.—Chairman: Dr. E. Trible Gatewood, Professional Bldg., Richmond 19, Va.
Middle.—Chairman: Dr. Lawrence R. Boies, Medical Arts Bldg., Minneapolis 2.
Western.—Chairman: Dr. Clarence A. Veasey Jr., Paulsen Bldg., Spokane 8, Wash.

American Otological Society

President: Dr. Gordon Berry, 36 Pleasant St., Worcester, Mass.
Secretary: Dr. Gordon D. Hoople, 713 E. Genesee St., Syracuse, N. Y.
Time: May 31-June 1, 1946.

American Otorhinologic Society for the Advancement of Plastic and Reconstructive Surgery, Inc.

President: Dr. Alfred Schattner, 115 E. 61st St., New York.
Secretary: Dr. Norman N. Smith, 291 Whitney Ave., New Haven, Conn.

* Secretaries of societies are requested to furnish the information necessary to keep this list up to date.